MECHANICAL ENGINEERING

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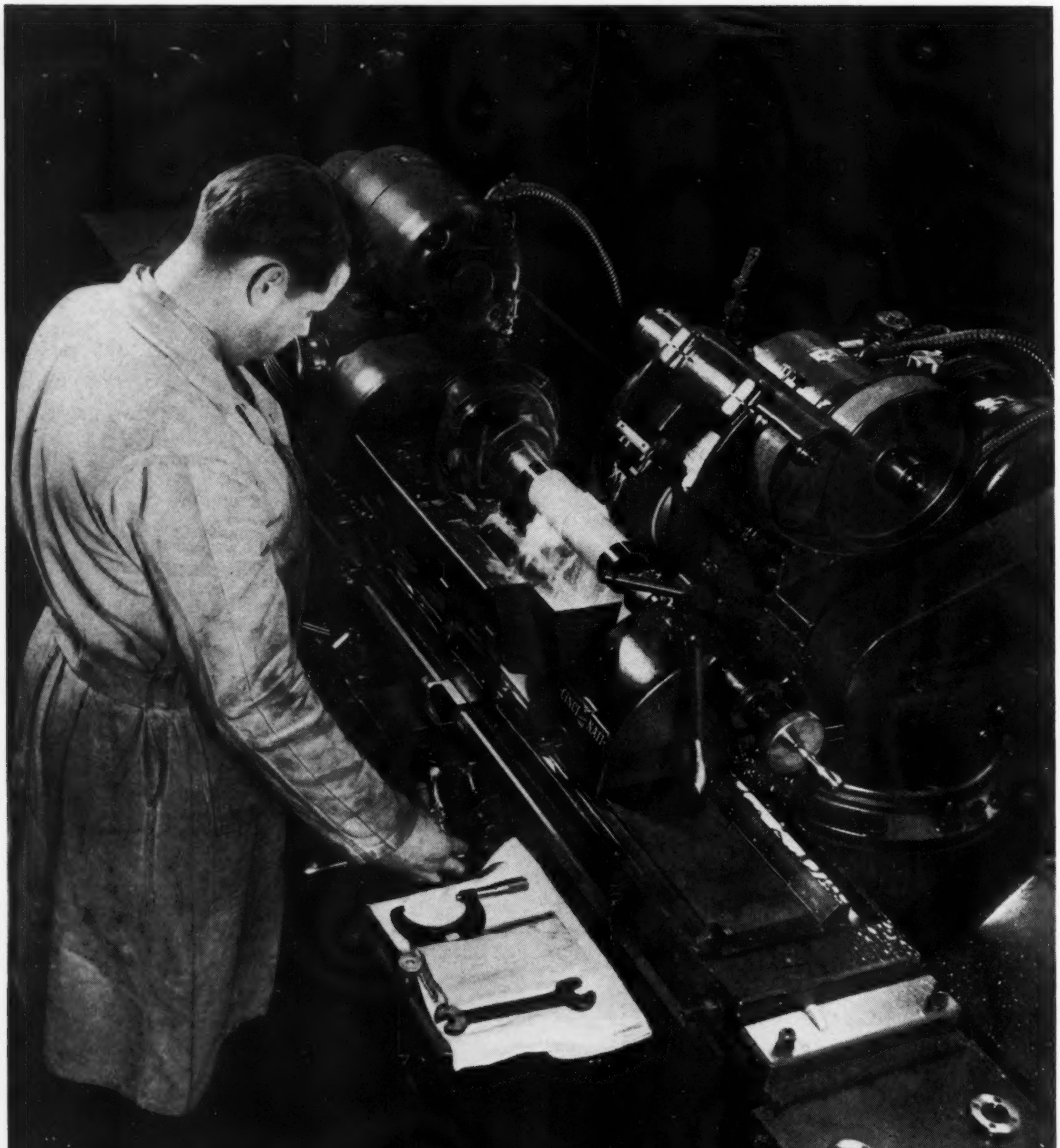

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Men and Machines Against Time—A Grinder in a Toolroom Working for National Defense

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MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

A Role for Engineers

ENGINEERS should find some way to pluck William E. Wickenden out of his administrative duties as president of the Case School of Applied Science and from his important services at Washington in the cause of national defense and send him around the country for a few months at least, to carry to all engineers and their well-wishers the message he delivered on February 7 to The Engineering Institute of Canada. A liberal portion of Dr. Wickenden's address is reprinted on pages 297 to 299 of this issue. The reading of it will start many minds off on a track of wishful speculation and, it is hoped, pious resolve to work for the advancement of the engineering profession, and it should also help to crystallize in the minds of readers some of the basic principles of professionalism. Probably Dr. Wickenden cannot be spared from either of his important posts at this time, but one wonders if he might not at some future date speak on this subject to many groups and bring within the influence of his personality men who, awakened to the high purposes his address sets forth, would immeasurably raise the level of the profession in which they find themselves and coincidentally make a better world for their fellow men.

It is a satisfaction to direct attention, for the purpose of emphasis, to a portion of Dr. Wickenden's address that covers a point frequently urged in these pages. This refers to the strategic position held by engineers as managers of enterprises, in whole or in part, where their intermediate position between owner and employee vests them with responsibilities to both and equal responsibilities to the public served by these enterprises. Few thinking men doubt the inevitable social and economic changes that the future, conditioned by world-wide upheaval of which the war is a horrifying witness, may hold in store. The industrial era of modern civilization is working toward its climactic phase, during which the pattern of economic, social, and political life will either be woven into a strong fabric of more wholesome relationships or be replaced by one that is alien to most of us.

Just as engineers hold the key position in respect to the military conflict that is spreading so rapidly over the globe, so also they may occupy the position of determining influence in the unpredictable events that inevitably will accompany peace. But to exercise to beneficial purpose the influence that may be theirs, engineers must rapidly assume a habit of intellectual maturity in the chaotic field of human relationships. They alone cannot insure the character of the pattern of things to come, but, aided by thousands of men of sound judgment and intelligent understanding of the rapidly developing history of our times, they afford the most hopeful instrumentality by means of which a better world may be built.

Dayton C. Miller

FOUR lectures are indelibly fixed in the writer's mind. One, heard when a boy, was by Walter P. Bradley and the subject was liquid air. An overflow audience crowded into the Hyperion Theater, and Professor Bradley, with a milk can of liquid air, brought to town against the better judgment of the railroad, made "steam" in a teakettle on a block of ice and shattered a sirloin steak as brittle as glass.

The second was Arthur H. Compton's address, "What Is Light?" Never were demonstration experiments and the projection lantern synchronized more effectively. Behind a long table the Nobel prize winner spoke with great assurance. Assistants brought off every demonstration successfully without apparent orders. The room was darkened and the pictures appeared on the screen at just the right moment—not one was upside down or in the wrong order.

Another laureate in physics, Irving Langmuir, gave the third. He entered the crowded auditorium with a box of slides, but by oversight there was no lantern or operator. The audience never missed them. So graphic was the great man's description of his work with monomolecular films, so simple was his language, that one wonders what possible addition the slides would have been. For supreme composure in a situation that must have changed the pattern of an important lecture, the incident was a memorable one.

Dayton C. Miller, physicist and flautist, was responsible for the fourth treat. He talked about sound on a stage crowded with every conceivable variety of flute-like instrument and much scientific apparatus. From the oat-straw pipes of Arcadian shepherds and the reeds of the goat-hoofed Pan, to the gold, silver, and glass flutes of a more sophisticated age he showed "the only way, since gods began, to make sweet music, they could succeed."

For those who wished science with their music he spoke of pure tones, of harmonics, and overtones, of beats, dissonance, and unmusical noise. With a beam of light that danced merrily over a screen he showed the characteristic traces of all these sounds, and on the blackboard wrote equations in Fourier's series that froze

music into mathematics. Surely, he insisted, there must be some elemental harmony between the beauty of line and the beauty of sound. On the screen he showed the most beautiful curve he knew, his wife's profile. Turned through ninety degrees it looked like one of the curves he had reproduced with the dancing light beam. And the equation of the curve proved it to contain only a fundamental note and its harmonics. It was the curve of such a note as might linger at the close of an overture.

Dayton Miller died in Cleveland on February 22. He was beloved by student and colleague. He was known the world over for experiments in ether drift. He had one of the world's greatest collections of flutes. But to one who saw him only once there remains the memory of a white-haired man, a flute poised gently against his lower lip, while facile fingers moved nimbly over the keys, and of clear pure notes that had been accurately described in the language of mathematics, a harmony of beauty in sound and line, and a vibrating column of air made visible by a brilliant understanding mind.

Salute to Mechanics

WHAT is there more fundamental to mechanical engineering—to all engineering—than mechanics? Without mechanics we have no structures, no machines, no products. Nature herself is obedient to its laws. According to these laws the stars move in their courses, the earthly seasons repeat their cycles, night follows day and day the night. Because of them man is bound in time and space unless he has wit to use them to loose such ties. Mountain and plain appear upon the stressed surface of the earth, rivers seek their channels, the oceans cover the depths, and above all the air moves, the clouds form, the sun's rays are absorbed and tempered, and life itself unfolds or ceases to exist. Guided by his knowledge of these laws, man interposes his structures and his mechanisms to seek protection or to increase his natural powers, to ameliorate as best he can the rigors of his environment and to find the happiness and satisfaction toward which he is urged by inner forces. Defiance of them, whether through ignorance or well-intentioned desperation, is fatal, for their ultimate authority is truth itself, whether it be fully or only partially revealed. None can escape this authority, but those who work in harmony with it have great rewards.

Without mechanics in its broad sense the engineer—the designer, the producer, the operator—is helpless. Whether his particular dependence is upon statics or dynamics, on the mechanics of materials—gaseous, liquid, solid—or the mechanics of energy transformation, he must fall back on the fundamental laws, and to advance he must uncover ever more truths. Toward this end Newton served; to assist him in his analytical methods he turned to mathematics, that universal and economical language of precision, for which he devised a new system, which he called "fluxions" and which we today know in the modern form of the calculus.

Universal and precise as this language is, it is acquired by relatively few, easily forgotten, and scorned by the ignorant. Yet how convenient it is to state the first and second laws of thermodynamics in such simple language as:

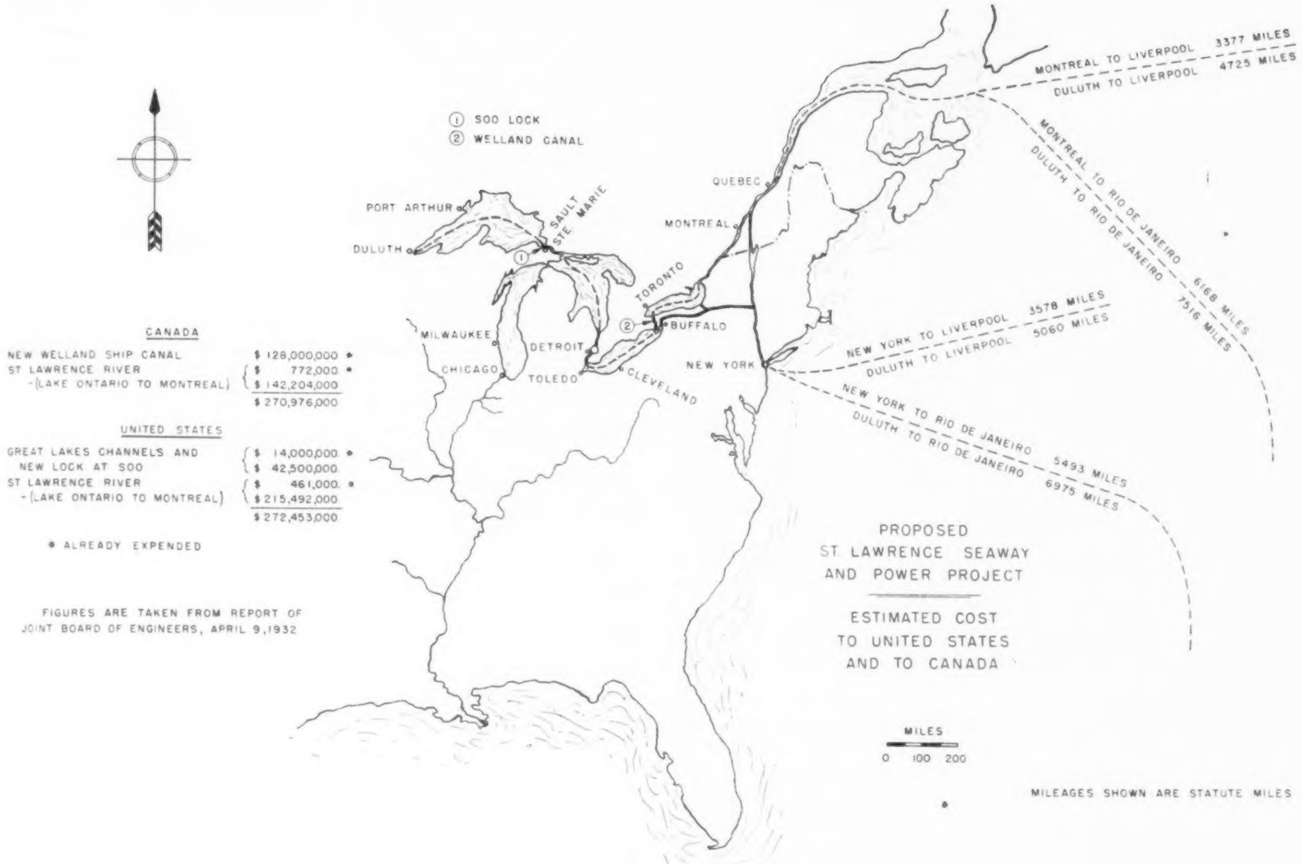
$$dq = du + Apdv, \text{ and } dq = Tds$$

At the 1940 National Meeting of the Applied Mechanics Division Professor Timoshenko asked one of the members present who quoted an authority on naval architecture if he could read Russian, the only language in which the work referred to was printed. "No," was the answer, "but I could follow the mathematics so it wasn't necessary to understand the Russian." What better evidence is needed of the universality of the mathematical language?

This is not to deny that mathematics itself needs interpretation in terms of reality. Another case comes to mind of two collaborators, a mathematician and an engineer. By purely mathematical methods the former works out relationships that have no special physical significance to him. But pondering upon these relationships in terms of physical concepts rather than mathematical symbols the engineer discovers the significance in terms of the realities of natural phenomena and applies them to his daily work.

Sometimes the mathematical analyst and the "practical" engineer are combined in one person. If, as in the case cited, they are not, then perhaps a happy combination works out to the advantage of both. In many respects, this is the relationship of the Division of Applied Mechanics to The American Society of Mechanical Engineers, although there is no intention here to suggest that members of the Division do not comprehend the significance of the mathematical equations they derive. What it is intended to suggest is that nonmathematical members of the Society are greatly enriched by those who can perform these feats of analysis and express relationships in a precise form for the use of others. More often than not, perhaps, these relationships have significance far beyond the special case for which they represent a general solution. No need to be a mathematical analyst if one can comprehend the realities suggested by the solution.

Fortunate it is for the A.S.M.E. that it has this group of applied-mechanics experts within its own membership. A society of applied mechanics, divorced from an engineering atmosphere, might easily soar into the realms of pure mathematics. A society of engineers without mathematical analysts might blunder along with empirical and cut-and-try solutions, ignorant of the fundamental nature of realities involved or their significance. A real engineering society must have both types of engineers in its membership. A student of mechanics wastes little time on perpetual-motion machines, but let him discover the factors on which high efficiency depends and the engineer will produce the design most likely to approach the ideal maximum. Time and education operate in favor of a greater extension of our knowledge and use of mechanics. Toward this end the A.S.M.E. Applied Mechanics Division is making significant contributions.



INLAND OCEAN

By L. K. SILLCOX

NEW YORK AIR BRAKE COMPANY, NEW YORK, N. Y.

Modern civilization is served by two major agencies in the field of mass transportation—shipping by water in natural, improved, or artificial channels and overland transport by rail. Each is entitled to its mass transportation classification by virtue of the capacity of the cargo units which it employs and the total tonnage which each can handle in a specified time by the intensive utilization of its facilities. In the case of vessels operating in domestic service on the Great Lakes or upon navigable streams, rivers, and canals, intercoastal, and in foreign trade on the ocean, limitations as to dimensions are fixed only by the size of locks through which the ships may be required to pass or by adaptation to the physical peculiarities of the water courses and harbors which they will patronize. Some Mississippi River towboats are capable of handling as much as 12,000 tons on barges at five miles per hour on the lower river. Large Atlantic cargo vessels will transport nearly as much, cradled in a trackless medium so expansive that only port clearances, loading facilities, and minimum draft at the ports of call need be considered in their construction. Under most favorable circumstances, railways, too, haul 12,000 net tons in single train units. Seventy tons per car, 185 cars per train, are not unknown in short-haul ore trains operating from mines to ore docks on the Great Lakes. Bituminous-coal trains commonly haul 9000 tons on relatively fast schedules although 3000 and 4000 tons comprise representative high tonnages in trains of mixed commodities. There would be no uncompromising limitation upon railway tonnage per train were overland transportation given the same point-to-point latitude in clearances which ocean shipping enjoys. Railways must respect infinite clearance limitations through tunnels, bridges, cuts, and highly developed industrial areas. Compelled to own and maintain out of revenues all the real property delegated solely to their use, extravagant clearances would be impractical. Yet one cannot visualize the type of equipment which railways would employ or the length of train which would emerge were all railway operations confined to nonstop runs of from 2000 to 8000 miles. The relative flexibility of railways as compared with competitive services by water, the direct routes over which they operate, and the speed with which railway freight is moved define a railway service unrivaled by any competition with equal tonnage capacity.

An address delivered at the Graduate School of Business Administration, Harvard University, Jan. 9, 1941.

ARTERIES OF TRADE

Before men had the facilities with which to build and operate railways, it is natural that they should have exploited fully the potentialities of natural water courses. Industry and trade

settled along the seaboard and on the shores of navigable streams. Productive territories were gradually enlarged by reconstructing inadequate channels and cutting new ones to tap undeveloped agricultural, forest, and mineral resources. River craft were adapted to the capacity of streams as they were found or to the common four- and six-foot drafts imposed by early canal specifications. Centuries would have been required to tap vast production of rich inland regions had not railways discovered their ability to provide mass transportation over cheaply constructed branches. These lateral spurs often extended into sparsely inhabited wildernesses with the hope and prospect that someday the traffic which they encouraged would compensate them for their pioneering expense and justify improvement of the line. There was not much to recommend railways competitively with established parallel water routes until after the Civil War, when railway service expanded to provide an artery, coast to coast. Improvement in facilities and service developed simultaneously with total railway mileage. Waterway shipping suffered a serious decline in all territories, yielding to the implacable law of transportation economics.

ECONOMICS OF WATERWAYS

Tonnage can move cheaply by water, competitively with railways, when great vessels can be employed, favored by deep, natural channels, free from great storms and swift currents; where long distances minimize rehandling expense; and when both origin and destination of cargo are accessible to the water route. Were these natural restrictions upon the economics of waterway transportation respected in all cases, railways would have no quarrel with waterways in the distribution of traffic, and inland-waterway tonnage in substantial volume would move only over the Great Lakes and the lower reaches of the Mississippi River and its important tributaries within the limits of our country, coastwise, and from coast to coast. This concedes the Soo Locks and the Welland Canal, where development cost probably is commensurate with the benefits. It allows the Panama Canal, a valuable artery in world trade and essential for national defense. Some development of the Mississippi River for navigation purposes may be justified as a complement to flood control. It cannot justify the New York State Barge Canal, the federally sponsored Inland Waterways Corporation with its 12,500 circuitous miles of costly rail-competitive water route, many of the minor developments on more than 200 other rivers and streams, or the improvement of the St. Lawrence River to provide a 27-ft channel connecting the Great Lakes with the Atlantic Ocean.

THE SEAWAY IN CONTROVERSY

A project such as the St. Lawrence River Deep Waterway Canalization and Power Development frustrates all attempts toward impartial evaluation. A truly national enterprise, it is variously promoted and condemned on purely sectional bases—advocated and refuted by special interests which are not representative of considered national judgment. The expense, which eventually must be met by a levy upon the citizens of both participating countries, though the burden would be postponed by the temporary process of further increase in the national debt and debt service, will be incurred at the insistence of political pressure groups or favored industries and trades. New York State, destined to pay $90,000,000 for its power privileges and to support an estimated 50 per cent of the total cost to the United States by virtue of its title to developed power and its participation in the national expense, is clearly divided. The proposition is viewed with disfavor by the majority comprising the Metropolitan area which sees a possible diversion of Atlantic shipping from the Port of New York; by the Albany region which now enjoys an inland seaport as well as canal service to the Great Lakes; by the Barge Canal interests including the cities along its route; and by the southern counties which, being fairly remote from the source of power generation and conveniently located with respect to the bituminous-coal fields of Pennsylvania, vision local costs disproportionate to local benefits. Northern New York, on the other hand, dreams of a great industrial empire, attracted by an unlimited amount of cheap power. Few ports on the Great Lakes are enthusiastic in their views of the project, counting the quarter-billion-dollar total cost of harbor improvements at ten major lake ports to accommodate an unfamiliar type of vessel which demands at least two feet of water beneath a deeper keel. The Midwest farmer, who still routes his grain through the Lakes for the export trade, hopes for an increase in value of his produce if subsidized transportation lowers the cost of delivery in foreign markets. Railways serving the territory between the Midwest and the Atlantic seaboard know they will suffer to the extent that the navigation project succeeds. The coal and public-utilities interests are obviously confronted with substantial loss. The maritime interests of the Great Lakes would suffer in so far as ocean shipping under foreign flags diverted tonnage originating with or consigned to interior points. Operators of ships of American registry do not care to face more effective competition from foreign vessels with their lower initial and operating costs. Emphasis upon the need for the proposed St. Lawrence development vacillates between transportation and power. Current choice bespeaks the advocates' poll of public opinion.

GENESIS OF THE PROJECT

Seaway proposals are of no recent origin. Inland exporters have sought the cheapest and most direct route to Europe since their first years in foreign trade. An international waterway commission was established in 1895 but its achievements were negligible. There followed, in 1909, the International Joint Commission, appointed to arbitrate boundary disputes between Canada and the United States but engaged from time to time in investigation of coordinated action between the two countries, favorable to river development for navigation. This commission never has been dissolved and a recent effort to secure resignation of three members has been interpreted by some students of government in its relation to vast federal expenditures as an attempt to reduce the commission's conservative majority. Its self-sponsored investigations never took the form of recommendations for construction and it served its charter function quietly and without interference until, with the conclusion of the World War in 1918, and the taxing of railway capacity in the handling of the western grain movement for export, the farmers were organized to request specific investigation of an all-water channel to Europe without transshipment.

MIDWEST PRESSURE

A meeting was held in Duluth in 1919 at which the Great Lakes-St. Lawrence Tidewater Association was appointed to press the International Joint Commission for St. Lawrence River improvement recommendations. President Harding and Prime Minister Meighan appointed engineers to cooperate with the Joint Commission in its work. In the following year a report, favorable to construction, was submitted, remarking the permanence of the project and its low maintenance cost. The formal recommendation of the International Joint Commission followed in 1922, suggesting that a treaty well might be drafted with a view toward joint participation in improvement of the border waters to accommodate ocean shipping. Under President Coolidge, and originating with overtures addressed to

him by the British Embassy, the engineering staff of the International Joint Commission was enlarged to six men and a thorough investigation of construction details and costs was undertaken. The St. Lawrence Commission of the United States was formed with Herbert Hoover, Secretary of Commerce, as chairman, consisting of nine members, all selected for their sympathetic attitude toward the joint enterprise. Canada simultaneously appointed a nine-member committee of its own to conduct a similar but independent survey, reporting upon the extent and direction in which Canadian interests would be served. These committees reported to their respective governments late in 1926. The power potentialities of the river development were combined with navigation benefits in the report of each committee, introducing for the first time a second argument for river development. The reported total cost as derived by these committees was the nominal total sum of $274,742,000 for all improvements required in the St. Lawrence channel. The United States commission viewed the development as "imperative" to the interests of the interior states. It also delegated to New York State the power privileges and a proportionately higher burden in the cost.

DRAFTING THE TREATY

A period devoid of active new international developments extended to late 1930, when President Hoover again initiated correspondence, culminating in the joint settlement with the Canadian Prime Minister upon the first St. Lawrence treaty in July, 1932. Meanwhile, the Canadian locks in the Welland Canal had been reconstructed to provide a minimum depth of 30 ft. The Beauharnois hydroelectric development at Montreal has since been placed in operation. Reported favorably by the Senate Foreign Relations Committee in 1933, and passed to Congress for ratification with the endorsement of President Roosevelt in January, 1934, the treaty failed to receive Congressional acceptance by the narrow margin of twelve votes in March of the same year. Pending reorganization of arguments and accumulation of new data in support of the St. Lawrence construction, international negotiations proceeded quietly until 1938. Meanwhile, Canadian war effort removed much of the determined Canadian opposition which had been met. Canada recognizes the value of an abundance of cheap St. Lawrence power, particularly if available at low investment expense by virtue of the share in dam construction cost and channel work which the United States would assume. Still, Canada presents no united view.

THE SECOND TREATY—1938

A new treaty was drafted in 1938, rewritten in many parts in the words of the former document but obviously stressing the importance of the power possibilities, both at Niagara Falls and in the international section of the river. The responsibility of each country for new work is specifically stated: Canada to complete the 27-ft channel through the 30 miles of the Welland Canal (the locks already furnish 30-ft draft throughout their combined length) and to provide ocean-draft channels around the Soulanges and Lachine rapids; Canada to construct a channel with locks to by-pass the lower dam at Barnhart Island; the United States to assume all costs of improvements for navigation purposes in the international section and to construct a channel with locks around the dam at Crysler Island; the United States to deepen all upper lakes channels; each country to participate in the cost of improvements for power purposes in the international section. The revised treaty lies dormant in the files of both countries.

THE EXECUTIVE ORDER OF 1940

On Oct. 16, 1940, an Executive Order was drafted and presented to Congress by the President on the following day. The order provides: the allocation of one million dollars from the President's special defense fund for preliminary investigations which will culminate in a report of all engineering details associated with the prompt execution of works necessary for full development of hydroelectric power in the international section; the appointment of a special committee of four, representing (1) the Federal Power Commission, (2) the presidential cabinet, (3) the Corps of Engineers, U. S. Army, and (4) the Power Authority of the State of New York; consultation with delegated Canadian authorities.

NAVIGATION AND POWER INSEPARABLE

A number of arguments predominate in the case for and against joint construction with Canada of public works in these important border waters, whether such construction has to do with power development or navigation. Upon every practical basis these objectives are closely interrelated. Should either be accomplished, a far step will have been taken toward realization of the other. The cost, which can be specifically assigned to either one, may be commensurate with possible benefits after the other has been independently accomplished without regard to its cost or economic justification. Certainly, there can be no clear case for navigation when, bolstered by a tremendous power argument, unrevealed in the first arguments, the project still remains one of severest controversy.

POWER-PROJECT OPPONENTS

The case for power development, the current issue, rests upon a need for national defense and an alleged peacetime shortage in the Northeastern States. Among its opponents, other than those who object because of the indirect impetus which the necessary power dam construction would lend toward navigational developments, are numbered: The United States coal operators; the utilities interests which operate in the territory which the St. Lawrence development would serve; the eastern railways which would lose coal traffic for supplying steam-power stations but which might receive some compensation through the relocation of industry and the stimulation of the mineral industries in the section; and the taxpayer of the United States, more especially of New York State, who does not expect any personal benefit, however it might be derived, of the order represented by the investment he would be required to make.

POWER SHORTAGE

In the words of the President's message to Congress of Oct. 16, 1940, ". . . . the Aluminum Company has recently arranged for the import of 30,000 kilowatts of additional power from Canada . . . subject to being withdrawn if required by the Canadian power market." This doubtless is a true and accurate statement. It bespeaks a Canadian power surplus resulting from hydroelectric developments at a number of favorable sites and the low energy rates which are common to surplus commodities. It does not mean that an equivalent or greater amount of power could not be made quickly available through generation in the United States if withdrawal of the present source were in prospect. That the Aluminum Company elects to import power, and the power interests of the United States have taken no prior steps to enlarge their capacity in anticipation of demand and to compete with the Canadian market, is evidence of the surplus-power rates which the industry now enjoys.

CANADA'S NEEDS AND RESOURCES

The President continued, "The Province of Ontario needs to be able to count upon the early availability of this power to meet its growing load." There is a present Canadian surplus

and there are many attractive Canadian sources for hydroelectric generation if it were necessary or desirable to augment production. The Province of Ontario is insured an abundance of power for the next two years through contracts written with power interests in Quebec. Any prospective increase in power consumption due to war effort has been taken into consideration. New projects are to be completed in the Province of Ontario before these contracts expire at the end of 1942—enlargement of the Chat Falls plant on the Ottawa River and a new plant on the lower Ottawa at Carillon. A 300,000-hp plant at De Cew on the Welland Canal is under consideration. Scarcely more than 10 per cent of the water-power resources of Canada which are subject to practicable development are being utilized although current installations total nearly five million horsepower. Complete development of the St. Lawrence River would, alone, almost double this amount of energy. It would add approximately four million horsepower (more than one million at the international dams), almost two million in the Soulanges section, and another million at the Lachine rapids. The more than 20 per cent increase from the international section alone would require a greatly expanded Canadian market for power, which is not now in evidence, and other falls of uniform flow and high head can be harnessed at lower capital cost per available power unit. There are nearly one million available horsepower undeveloped on the Ottawa River and more than another one million on streams flowing into the upper Great Lakes. Flow at the great Beauharnois dam, already constructed and less than 60 miles from the Aluminum Company's plant of Massena, N. Y., justifies the installation of generating equipment which would increase capacity by one million horsepower at this site. Provision for the expansion has been made and only installation of the necessary generating machinery is required to recover this power. Canadian hydroelectric equipment at Niagara can utilize nearly 18,000 cubic feet more water per second than are now allowed. This would produce an additional 200,000 hp. Similarly, if the Schoellkopf and Adams plants of the Niagara Power Corporation (U.S.A.) were allowed sufficient water for capacity operation, another 180,000 hp would be produced. Thus, there already are installed generators of 380,000 hp capacity in the United States and Canada at Niagara which could be put into operation instantly by simply raising the gates and letting the water flow through. The cost would be represented by some sacrifice, probably imperceptible if one were not advised, in the beauty of the falls and even this could be corrected by the construction of the long-planned diversion weirs to distribute flow over the crest of the falls.

NIAGARA

Under the treaty of 1909, Canada is permitted to divert 36,000 cfs of water at Niagara. The United States is given 20,000 cfs by the same treaty. By changing the course of the Albany River to lead its waters into Lake Superior, Canada has earned the right to utilize 5000 cfs additional at the falls, equivalent to 105,000 hp. The rewritten treaty of 1938 would permit diversion of another 5000 cfs by each country, a total of 46,000 cfs to Canada, 25,000 cfs to the United States, under a plan which would maintain the beauty of the falls and distribute the fall more uniformly, retarding erosion. Agreement on these details should be concluded apart from other treaty provisions since nearly 400,000 more horsepower would become available at the falls at a cost of one and three quarters million dollars. A further plan for almost complete interruption of the flow from Lake Erie during the night would tremendously increase the amount of water available and the output over limited periods without interference with the famous spectacle of the cataract during the daylight hours and even this latter inheritance well might be sacrificed temporarily in the face of a joint national crisis. Lake Erie provides an average flow of 130,000 cfs into Ontario over the Niagara cataract. Complete utilization of all this flow would quickly provide over four and a half million horsepower for temporary and emergency use, more than twice that which could be generated at the international dams. No estimate of the time required to produce power at the international St. Lawrence section contemplates a construction period of less than five years. The emergency power requirements of Canada, if they will exist in the near future, can be more reasonably and more promptly met in other ways.

NORTHERN NEW YORK

Northern New York State will strongly support the President in his effort to encourage construction on the St. Lawrence even though the state may be required to pay heavily for the power accruing to it. Taxation to support the cost would be distributed though possible direct benefits would be concentrated within a relatively small area. A federal levy may be arranged even though power alone is the issue and New York State holds title under all agreements which have been discussed. However the cost may be spread, the civic interests of northern New York are confident that their region will benefit. Industries are visualized competing for New York State sites adjacent to the power source which will offer an abundance of cheap energy. Cleveland, speaking for the Midwestern industrial area, agrees that this might occur. It quite properly visions the relocation of industry, not the stimulation of new enterprise, with all the social hardships which attend a migration of this character. It is prophesied at a time when tax-ridden industry in the state is seeking to escape from the present burden. Cheap water power, made cheap by state subsidy, may still so increase total cost that a location in the region of economical transmission of St. Lawrence power will not prove as attractive as its advocates suppose.

OPPOSITION BY THE COAL INDUSTRY

The coal industry of the United States opposes the St. Lawrence power project. It is able to mobilize many more arguments against the eventual development which embraces navigation. As long as power generation remains the single theme, the coal operators will be penalized only to the extent that hydro power will supplant steam generation and the coal requirements of railways within the territory will be reduced. Railways serving the St. Lawrence area would have little occasion for concern were the prospect for the seaway eliminated rather than advanced by the hydroelectric development. Railways too would suffer through diminished consumption of coal and its corresponding rail movement. The specter of the vastly simplified step required to provide navigation, once the great dams have been constructed, outweighs the prospect of augmented tonnage arising from increased production in the area.

ECONOMICS OF STEAM

The coal operators point out the competitive nature of modern steam-power generation. From three pounds in 1920, the consumption of coal for the production of one kilowatt-hour of electrical energy has been reduced to 1.41 lb in modern, high-pressure-steam stations. Prospective annual costs indicate generation expense of St. Lawrence power to be not less than 2.8 mills per kwhr at the generating station, about the same as the cost of power at the Niagara Falls plants. This assumes a market for the entire production of the plant—a condition which cannot be realized unless the investment in existing plants is abandoned to permit the new station to carry

the entire upstate load until such time as a tremendously augmented demand is produced. At 50 per cent load factor on the hydro station, steam generation becomes cheaper.

THE SEAWAY

The most engaging study dealing with the economics of the St. Lawrence development occurs when the navigation issue is introduced. In one particular phase, built around the arguments of the coal operators, there is opportunity for a type of long-range planning which has found no place in all that has been written and spoken, in either defense or opposition to the proposal. It correctly can be stated that the coal operators would suffer to the extent of production amounting to more than five million tons of coal annually if the international development delivers 1,100,000 hp each hour of the year to displace power which otherwise would be furnished by steam plants. Looking forward to ultimate development, an annual loss of business to the coal operators of from thirty to thirty-five millions of tons is envisaged. It is claimed that navigation would destroy the Canadian market for coal mined in the United States. This has amounted to as much as seventeen million tons in one year and amounts to about ten million tons at this time. There is a forty-cents-per-ton Canadian tariff differential, favorable to the British importation. With British coal available at every Canadian lake port, delivered in bottoms which load at English docks, the advantage which has sustained traffic in export coal from the mines in the United States would be lost. Such vessels are expected to return with production of a newly industrial Canada, stimulated by its larger share of power residue from seaway construction and challenging established United States enterprise. Fear is expressed as a result of competition with many home resources from foreign exports cheaply delivered. Cheap coal from Great Britain and Russia would flood our markets—crude petroleum and fuel oil would flow freely from Venezuela, Russia, and other fields outside our borders. Foreign pulp wood would threaten a growing paper industry in the South. Every competitive mineral would be available at interior ports, more cheaply, no doubt, than it can be produced under American standards, despite probable tariff modifications. All this might not be a bad thing for our land if our economic system were constructed to respect any long-range benefits which might accrue from preservation of our irreplaceable natural resources.

COST OF THE PROJECT

Competition with importation of equivalent natural resources does not constitute the sole argument for or against seaway construction. The nation, jointly with Canada, is faced with a proposal to invest in a project, the cost of which is estimated to be anywhere from 543 million to more than a billion dollars. The Joint Board of Engineers submitted the lowest estimate. Former President Hoover submitted an $800,000,000 figure as the probable cost. Dr. Harold G. Moulton, conducting an independent survey for The Brookings Institution in 1929, set the cost at $999,000,000. E. P. Goodrich, a consulting engineer, thought the expense would total $1,054,000,000. Hugh L. Cooper, an international engineer, estimated $1,350,000,000. No doubt the survey now in progress will produce a new figure but one which is destined to be purposely attractive. It will embrace work required for power production only. Construction of the Panama Canal was undertaken with $160,000,000 appropriated for the purpose though $375,000,000 was spent before it was opened for traffic. Almost three times the original grant was required to construct the Suez Canal. $53,000,000 was required to construct the Chicago Drainage Canal, estimated at $16,000,000. In the Great Lakes system, Canada undertook construction of the Welland Canal with an allotment of $50,000,000. $78,000,000 more were required to complete it.

NAVIGATION

The arguments, which have been offered to discourage St. Lawrence River development for navigation, present many paradoxes. The Great Lakes carriers are able to show, through well-supported statistical data, that the economy of the lakes vessels is such that ocean shipping cannot afford to compete, even though the rehandling of export cargo would be eliminated. Atlantic steamship operators fear a complete disorganization of Atlantic shipping rates which could not occur in the absence of export and import tonnage moving through the St. Lawrence in foreign vessels. Dr. Moulton derives a small percentage of Atlantic shipping capable of passage through a 27-ft channel. The railways, the coal operators, and other mining and manufacturing industries of the United States which are competitive with foreign producers, gravely fear successful navigational objectives. There are many factors to be considered. In the light of present uncertainties, arising in some measure, no doubt, from the principles which individual agencies have endeavored to prove, any lay attempt to segregate and evaluate possibilities is met with many obstacles. All can agree that the tremendous waterway expenditure is wholly unjustified if the canalized river will not be used in the direct shipment of export tonnage in large volume. It is also certain that the necessary large volume cannot move through the canal without either depriving established carriers of the service they now perform if the present balance and tonnage of exports and imports are not grossly disturbed, or without seriously and detrimentally affecting American industry both north and south of the border if the canal encourages foreign competition in domestic markets.

LAKES SHIPPING

The efficiency of Great Lakes cargo vessels is graphically described by William H. Coverdale, president of the Canada Steamship Lines, Limited,[1] to refute the claim that the export rate on grain from the interior will be reduced materially when it can be moved in tramp ocean steamships from upper lakes elevators to foreign ports. Lakes grain boats carry 400,000 to 500,000 bushels of grain from head of the lakes ports to the St. Lawrence River, utilizing a draft of less than 21 ft; the largest of these has a capacity of 572,000 bushels at a draft of 20 ft, 7 in. A large ocean-tramp-vessel grain cargo will average half the tonnage of the lake bulk carriers, requiring a draft of 30 ft for even this performance. Offsetting the capacity advantage of lakes vessels with respect to foreign tramps, there is the higher initial cost of ships constructed in America, the higher wages and higher standards of sustenance aboard ship which Great Lakes seamen enjoy, and a short (225 days) season over which fixed expense may be spread. A large lakes bulk freighter will cost from $1,000,000 to $1,500,000, averaging about $90 per (long) ton capacity (1936 estimate). A tramp steamship of 7500 deadweight tons, built with cheap foreign labor, will cost but $375,000, or $50 per ton (1933 estimate) despite the additional strength which must be built into the hull to make it seaworthy for ocean voyages. Thirty-five men in the crew of the lakes cargo vessel will involve expenditures each shipping season of $40,000 for wages and $14,000 for provisions (1936 estimate). Thirty-five men on the ocean tramp will cost $15,000 for wages and $5500 for provisions over a period of 225 days (1929 estimate). At the present time, St. Lawrence River navigation to Montreal is carried out in canal steamships of 90,000 bushels capacity (2500

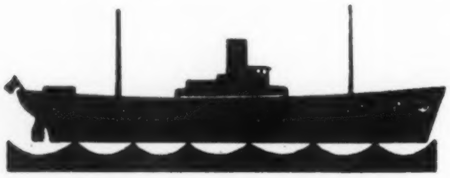
[1] "Some Facts on Canadian Grain Traffic," by William H. Coverdale, Bulletin, Chamber of Commerce, State of New York, January, 1933.

long tons approximately), valued at $225,000, based on a cost of $90 per ton, manned by a crew of twenty men, requiring season expenditures of $23,000 for wages and $8000 for provisions, again prorated on a personnel basis from lakes freighter operating costs.

CARGO-VESSEL CHARACTERISTICS

The typical Great Lakes cargo vessel is a steamship of from 550 to 640 ft in length with a 70-ft beam. The bridge and navigation quarters are located well forward in the bow. The power plant and living quarters for the crew, other than ship's officers, are in the stern. The whole intervening length comprises a series of battened hatches over which high lake seas are expected to sweep but which offer almost unobstructed accessibility to the holds for loading and unloading. Amidships, the vessel is substantially rectangular in section with very small radii at the bilges. Blunt bow and cruiser stern are typical, following conventional practice in the construction of freighters the world over. Since lakes steamships never encounter the maximum storms of the ocean, their form is practical and their plating and framing need not be as heavy as that of ships which sail the ocean. All the lateral stability they

GREAT LAKES BULK CARGO VESSEL
(Length, 600 ft; deadweight tonnage, 12,000 tons; draft, 20 ft.)



OCEAN TRAMP STEAMSHIP
(Length, 400 ft; deadweight tonnage, 7500 tons; draft, 24 ft.)

require is provided by two or three intermediate bulkheads and sufficient beam strength is obtained by a deep inner keel between the double bottom and the ship's skin, a space used for water ballast on empty movements. One Great Lakes steamer, 633 ft long, is credited with handling a record cargo of 17,160 tons at scarcely more than a 20-ft draft. In comparison, an ocean cargo vessel must be sturdily built to withstand seas which may balance the vessel amidships and then support it at its extremities. A typical tramp steamer of 24-ft draft, the maximum which is given as practicable for a 27-ft, fresh-water channel, will have a length of 400 ft, a 52-ft beam, and a capacity of 7500 deadweight tons. Its capacity is given as 280,000 bushels of grain, about half that of a typical lake freighter at four feet less draft. Should the river be canalized from the lakes to Montreal, providing 27-ft depth, the size and capacity of the lakes freighter would increase to take advantage of the new standard and its economy and resistance to ocean shipping competition on the lakes would be still greater.

GRAIN EXPORT CHARGES

Many distress rates are quoted upon the Great Lakes and, to a less extent, charges similarly derived depress ocean freight rates. When the coal movement to the head of the lakes exceeds vessel capacity required for the eastern shipment of ore, some ships will enter the grain trade to avoid a return trip in ballast. The last decade has witnessed rates as low as 1.75 cents per bushel for movement over the 866-mile lake route, including a 0.621-cent elevator transfer charge. Similarly, westward tonnage movement through the New York State Barge Canal predominates. To obtain some return revenue and to secure, at the same time, necessary bridge headroom through the canal, such operations sometimes bid for grain hauls at very low rates. A barge rate, Buffalo to New York, sometimes as low as 1.25 cents per bushel, is quoted in this service. At Atlantic seaboard ports, passenger liners again force distress rates by soliciting grain cargoes to fill out tonnage on scheduled sailings. The grain trade alone does not appear to be attractive though it is the traffic upon which the seaway arguments were formulated. The New York ocean grain rate is less than the Montreal rate by amounts ranging from 0.5 cent to 2.5 cents and this is in combination with a cheap movement via the New York State Barge Canal, despite the two transfers which the shallow canal draft requires. Mr. Coverdale is responsible for the following pointed cost comparison: With a lake-head-to-Buffalo grain rate, excluding the Buffalo transfer charge of 0.5 cent per bushel paid by the steamship operator, of 1.25 cents per bushel or 41.25 cents per ton for a distance of 866 miles, or 0.048 cent per net ton-mile, the cost is just two thirds the ton-mile rate charged between Liverpool and London at the normal rate of 6.0 cents per bushel or $2 per net ton for 2760 miles (0.072 cent per ton-mile). It is further pointed out that ocean vessels would be required to carry grain from the head of the lakes to Montreal at minimum competitive rates of 1.875 to 2.375 cents per bushel to meet the rates offered by existing facilities consisting of large bulk freighters to Kingston or another lower lakes port, and canallers, steamships of 85,000 to 95,000 bushels capacity capable of passing existing St. Lawrence locks, for the balance of the journey to Montreal. With a saving of 4 to 12 cents per bushel claimed as one advantage of the seaway to western farmers, the positive error of the argument is obvious.

ATLANTIC SHIPPING RATES

Ocean steamship rates are, for the most part, the result of negotiations carried out between members of shipping lines' "conferences." So disturbing has been the effect of free competition that the largest steamship operators who, at the same time, offer the most dependable service, have, for many years, settled among themselves the primary bases upon which their competitive operations will be carried out. The tramp-steamship operator, on the other hand, has resisted attempts toward general adoption of conference procedure. Independent or tramp operators are difficult to align Their business is conducted upon a relatively small and individual scale. Their operations are world-wide in scope, and all nationalities are involved. The relative magnitude of tramp shipping with respect to that of organized steamship lines determines the success with which conference rates may be stabilized throughout any shipping season and it is significant that, for many years, the total tonnage in tramp steamships has represented a diminishing proportion of the capacity in the world's commercial vessels. Among the important functions of the conference are numbered:

1 Formulation of freight and passenger rate and service classifications and the fixing of rates on various types of traffic.

2 The assignment of ports, frequency, and sailing dates of member lines.

3 The determination of size, type, and speed of vessels assigned in specified services.

4 The apportionment of traffic among member lines apart from port designation.

5 The administration of "money pools" whereby conference members contribute from revenues to a common fund which is distributed among the participants at season's end on some equitable basis.

6 The allowance of attractive rates to member lines (class B) whose smaller or slower ships, less frequent sailings, or circuitous routes require some discrimination in their favor for successful competition.

7 The standardization of practices in cargo charges based upon volume or weight.

8 The allowance of special commodity or berth cargo rates to meet current tramp operations.

All conference procedure must be formulated, of course, in respect to whatever port, joint rate, and facility regulations are currently in effect. The highly systematized operation of steamship lines, together with increasing national subsidies to encourage merchant-marine development in all maritime countries, has been responsible for the dignity and order in the busiest sea lanes in recent years. This organization would quickly be demoralized by any considerable increase in the success and expanding operations of the tramp steamship. It is this possible effect of the St. Lawrence Seaway which the North Atlantic conference fears. Once a 27-ft canal is opened and it is possible for tramps under foreign flags to call at the lake ports for export traffic, a demand for lower rates from seaboard ports will be heard. Some foreign vessels find it profitable to enter the lakes at the present time, sometimes discharging a part of their cargo at Montreal, inbound, and filling out cargo space at the same point, outbound, to satisfy the draft limitations in the restricted channels. If Atlantic rate concessions are made and the inland voyage is not profitable, the tramps, and a greater number of them is feared, will transfer their operations to competition at seaboard ports. In whatever direction the competition leads, Atlantic rates, already scarcely profitable, will be depressed, more liberal national subsidies will be required, and shipping will move in the direction of a national enterprise. Here it should be noted that the only commercial ships which sail under the flag of the United States without subsidy, are to be found plying their trade on the Great Lakes.

ST. LAWRENCE SEAWAY VESSELS

Dr. Moulton presents Table 1 to support his claim (1929) that less than 15 per cent of the passenger-cargo ships and approximately 5 per cent of the tonnage represented by such ships could make use of a channel offering a minimum depth of 27 ft. He also demonstrates the inability of 62 per cent of the tonnage and 85 per cent of the faster cargo vessels which now enter American ports, to navigate a 27-ft water course. His estimates are based upon a survey of arrivals at and departures from New York during the month of June, 1928. An analysis of the United States Maritime Commission Report of Dec. 31, 1937, shows no more than 30 per cent of the registered tonnage in ships of the world of more than 2000 gross tons capacity capable of navigating a 27-ft fresh-water channel. No vessel which does not afford a minimum clearance of $2^1/_2$ ft beneath its keel under present draft limitations through the St. Lawrence canals will be granted a Port Warden's sailing permit at Montreal. Allowing for settling 6 in. in passing from salt to fresh water, this means that a salt-water draft of not more than 24 ft probably will be allowed in the finished channel if the seaway were constructed to the agreed specifications of 1932. The survey of 1928-1929 is discouraging to the vision of mighty vessels passing through the St. Lawrence to the lakes. A similar survey, if it were to be conducted at the present time, would be still less impressive. Between 1932 and 1937, the Maritime Commission's report revealed decreases of two per cent both in the number and tonnage of registered vessels which could be accommodated in the proposed channel. Tendencies toward capacity and speed in modern cargo and passenger-cargo vessels demand deeper draft. Even the 30-ft channel between Montreal and the sea proved too shallow to permit use by important vessels which wanted to dock at Montreal and which Montreal wanted to attract. Work is now nearing completion, providing a 35-ft depth from the Port of Montreal to the sea.

TABLE 1 PASSENGER-CARGO SHIPS CARRYING U. S. FOREIGN TRADE, 1926, CLASSIFIED BY DRAFT GROUPS WITH REFERENCE TO A 27-FT CHANNEL[a]

Draft	Vessels in each class: Number	Vessels in each class: As percentage of total	Aggregate tonnage in each class: In gross tons	Aggregate tonnage in each class: As percentage of total
24′6″ or under	37	13.4	171,680	5.2
Over 24′6″	240	86.6	3,106,462	94.8
Total	277	100.0	3,278,142	100.0

[a] Compiled from unpublished data (excluding ships engaged in the Caribbean trade) supplied by the Bureau of Research, U. S. Shipping Board.

STANDARD SHIPS

One of the first responsibilities of the United States Maritime Commission under the Merchant Marine Act of 1936 was the rehabilitation of the merchant fleet of the United States and the Commission undertook the highly commendable project of originating standard ship specifications. Vessels of five distinct types have been launched or are building under the program, among which the passenger liner *America* is outstanding. Also in operation or under construction are Commission-designed tankers, three designs and capacities of ships which primarily are cargo vessels but which may be adapted to the accommodation of a few passengers, the C-1, C-2, and C-3 designations. Contracts have been written for more than one hundred vessels of one or another of these types, some to incorporate such modifications as appear desirable to adapt them to peculiar service requirements. It is the purpose of the Commission to encourage the construction of 500 such vessels, a total of nearly four million gross tons, within a period of ten years. In all probability, all will be in operation before the St. Lawrence Seaway could be opened to traffic, displacing a greater number of small uneconomical freighters now comprising the merchant fleet—ships of the type which could make best use of the canalized river. The brief specifications of Table 2, submitted by the Maritime Commission, relate to vessels of its design.

TABLE 2 BRIEF SPECIFICATIONS OF U. S. MARITIME COMMISSION SHIPS

	Passenger liner *America*	C-1 Cargo and passenger	C-2 Cargo vessel	C-3 Cargo and passenger	Tanker
Gross tons	26,482	6,900	6,085	7,886	10,600
Deadweight tons	14,361	8,975	9,758	11,975	16,400
Loaded displacement, tons	35,440	12,875	13,893	17,615	21,000
Cargo capacity, tons	4,000	8,047	8,055	10,026	129,000[a]
Length over-all, ft and in.	723–0	417–9	459–0	492–0	514–1
Breadth ft and in.	93–3	60–0	63–0	69–6	68–0
Shaft horsepower	34,000	4,000	6,000	8,500	12,000
Normal speed, knots	22	14	$15^1/_2$	$16^1/_2$	$16^1/_2$
Cruising radius, miles	11,000	10,000	13,000	14,500	
Compartmentation	3	1	1	1	
Number of holds	6	5	5	5	
Number of passengers	1,202	8	None	12	None
Draft, loaded, ft and in.	32	27–6	25–9	28–6	29–$8^1/_2$

[a] Barrels of 42 gallons.

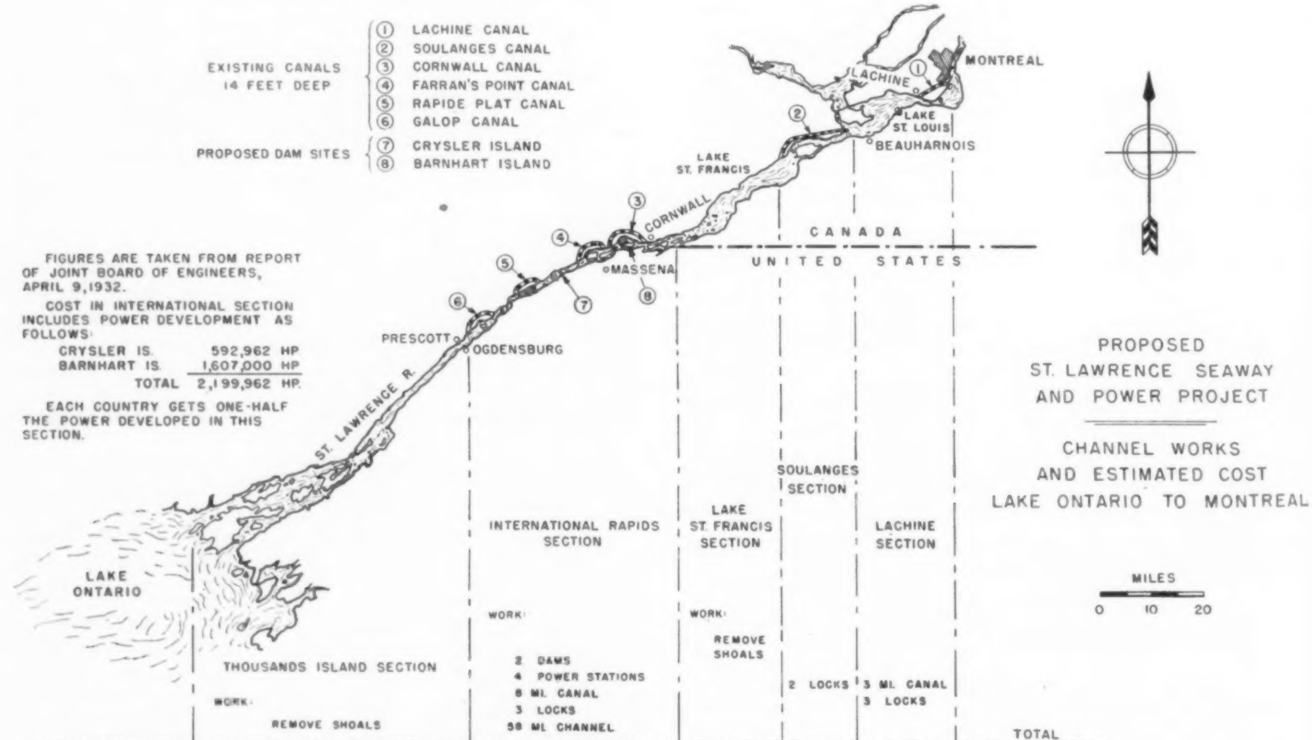
The most significant item of the specifications in its relation to the St. Lawrence Seaway is found in the draft required by the vessel under load. One shelter deck, C-1 design, calls for a draft of but 23 ft 6 in. These are salt-water submerged depths and reference is made to a ship's "particulars," the characteristic position it assumes in the water when under way—its "squat," the degree to which it settles by virtue of speed, on turns, or as affected by winds or currents—and its response to rudder and speed changes. Since the United States Maritime Commission ships are most accurately indicative of the modern trend in shipbuilding, the questionable commercial value of a 27-ft channel is apparent. However, a ship need not be loaded to its full weight capacity and many commodities do not permit maximum tonnage loading. Load adjustments may be made at Montreal in passing but purposely lightening a vessel results in uneconomical operation. Moreover, Montreal would obviously become a favored port. The rate advantage which New York now enjoys will be forfeited if ships entering and leaving the lakes are required to discharge or fill out a part of their cargoes in passing Montreal.

ST. LAWRENCE NAVIGATION

Ocean merchantmen, being relatively inefficient carriers as compared with lakes freighters, cannot operate economically at reduced speed or suffer the delays attendant upon passing several series of locks. Experienced navigators and steamship operators state that they would hesitate to subject their vessels to tortuous, fog-ridden, and rock-lined channels, even if large rudders were fitted to their vessels. Anchorages and passing under conditions of imperfect visibility would be hazardous. Narrow marked courses require local pilots, and ocean vessels cannot be maneuvered as can those which have been designed for canal operation. Responsible operators expect that the insurance rates exacted for protection of vessel and cargo through the St. Lawrence River will discourage much of such tramp tonnage as might otherwise move. It is difficult indeed to secure a favorable picture of the operation from review of any work which has been done on its analysis.

CONCLUSION

The St. Lawrence project has been promoted with two arguments predominating—low power costs to the area which is under its influence and low transportation costs of Midwestern production. A third argument, built up around a Canadian need for more power to promote her war effort and, simultaneously, a national-defense aspect, appealing to citizens of the United States, rises above the more familiar factors which have been discussed. Canada's unlimited resources in undeveloped power within the Dominion cannot be overlooked. Increased power demand in our own country can be more quickly and cheaply obtained by other means. The tremendous cost to every United States citizen of whatever rates advantage the Midwestern farmer may enjoy can be demonstrated without question. It appears doubtful that ocean shipping in volume would make use of a long, 27-ft channel if it were provided and the possible benefits to our country if it were used are not clear. The advantage of inland yards for the building of ships in the event our country were involved in war is not wholly clear. If our coastal shipbuilding plants should be endangered, a long and narrow channel, vulnerable to the destruction of locks and exposing helpless vessels on their way to the sea to the perils of modern warfare can scarcely be a solution—even assuming that the river works could be made quickly available. Despite the facility with which the fundamental purpose of the project can assume new forms, the necessity or the prudence, even yet, is not apparent.



	Thousands Island Section	International Rapids Section	Lake St. Francis, Soulanges and Lachine Sections	Total
UNITED STATES	\$ 461,000. (ALREADY EXPENDED)	\$ 215,492,000. *		\$ 215,953,000.
CANADA	\$ 772,000. (ALREADY EXPENDED)	\$ 59,250,000	\$ 82,954,000.	\$ 142,976,000.
TOTAL	\$ 1,233,000.	\$ 274,742,000.	\$ 82,954,000.	\$ 358,929,000.

* OF WHICH THE STATE OF NEW YORK WOULD PAY \$ 89,726,000 FOR POWER RIGHTS.

POWER-OPERATED RAKES *for* HYDRAULIC INTAKES

By G. T. ABERNATHY

HYDRAULIC DIVISION, NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY, NEWPORT NEWS, VIRGINIA

HISTORY

IT IS universal practice to place racks or screens at the intakes of hydraulic structures to prevent debris from entering the water passages downstream from the intakes. Screens may consist of perforated plates or wire mesh and are commonly used in connection with small intakes. Larger intakes usually have racks over the intake consisting of bars set vertically or slightly sloping so as to facilitate cleaning. It is the cleaning of these racks that is dealt with in this paper.

Much improvement has been made in the design of racks with the purpose of reducing head loss due to sudden contraction and expansion of the water-passage area. The early type of rack, consisting of flat-edged flat bars supported on standard structural-steel shapes, was improved by merely rounding the edges of the flat bars. Now some modern plants employ streamlined rack bars and supports. Regardless of how well hydraulically the racks are built, the accumulation of trash, logs, silt, and other debris remains the most influencing factor in reduction of head at the intake.

Although floating trash forms on the racks near the surface of the water, there is much submerged trash in the form of water-logged objects and silt that settles at the bottom of the intake. During heavy runs of trash, especially those that accompany floods in the autumn, the entire rack may be covered with trash so as practically to stop the flow of water through the racks. Fig. 1 shows a section of an intake rack taken from a hydro plant after such a run of trash.

Naturally, the earliest method employed for cleaning intake racks was by use of the hand rake. Hand raking can be satisfactorily done where the depth of racks does not exceed 15 or 20 ft and where the ordinary run of trash is of a small amount (1).[1]

The development of the power-operated rake was the natural result of progressive design of hydraulic structures. As intakes became larger in size and more in number at any one plant, the problem of hand raking became more acute. No doubt, the establishment and growth of power systems with interconnecting generating plants had its bearing on the development of the power-operated rake. The isolated hydroelectric plant, that could normally carry the system load alone, became a unit in an interconnected system, and as a unit could supply only a part of the system load. For most economical operation, the hydro plant had to utilize all the water possible that flowed past the dam for the generation of power. Thus during floods, the turbines were loaded to the capacity allowed by the generators or plant conditions. But floods carried the heaviest run of trash to reduce further the head already reduced by high tailwater. Thus it became increasingly important to keep the racks free of trash. Reports from a large number of plants that did not use mechanical rack rakes indicate that the outage time of the plant due to trash-clogged racks was in the neighborhood of 2 per cent (2).

Some of the earliest power-operated rakes were developed by B. J. Sloan, I. W. Jones, and W. O. Randlett (3). These rakes operated on the same general principle as do our present rakes although varied methods were employed to keep the rake open when lowering and guiding it properly over the rack bars upon hoisting (4).

INSTALLATIONS

There are about 110 hydraulic plants in operation in the United States that depend on power-operated rakes to clean the intake racks. Table 1 gives data on some of the outstanding installations. It is believed that the Diablo Dam outlet employs a rake with the longest travel of any in existence. The Osage rake is by far the largest power-operated rake built to date. Fig. 2 shows this rake with hoist and hoist carriage assembled at the manufacturer's plant. Here, two rakes are built on a common carriage. The larger rake is used to clean the intake racks of the main turbine units while the small rake is used to clean the racks of the house service unit. All of the rakes listed in Table 1 have individual hoists operated through reduction gearing by an electric motor.

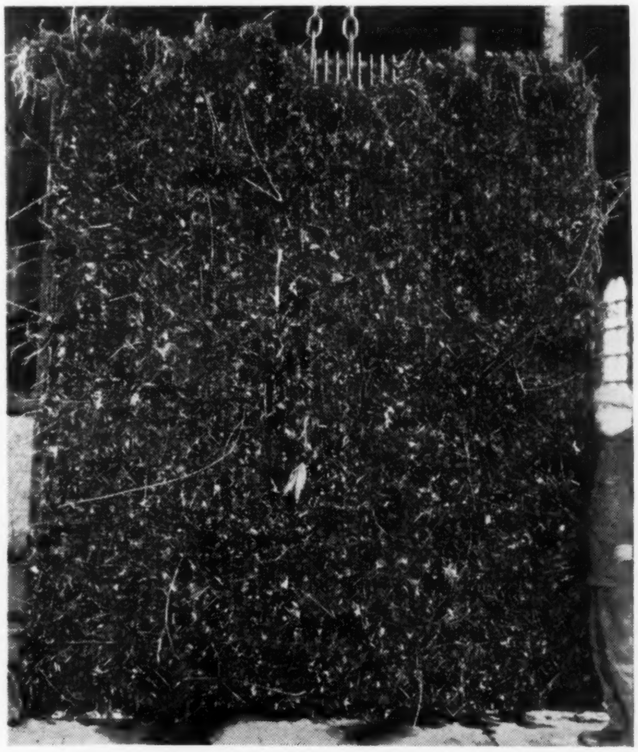


FIG. 1 SECTION OF TRASH-COVERED RACK REMOVED FROM AN INTAKE OF A HYDROELECTRIC PLANT

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Hydraulic Division for presentation at the Spring Meeting, Atlanta, Ga., March 31–April 3, 1941, of The American Society of Mechanical Engineers.

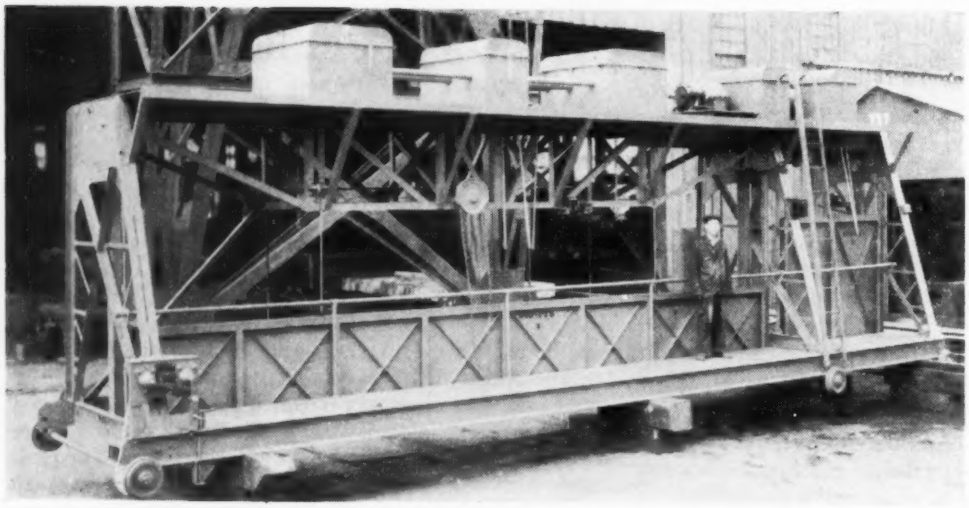


FIG. 2 VIEW OF SHOP-ASSEMBLED OSAGE RAKE, HOIST, AND CARRIAGE

OPERATION

The principle of operation of all power-operated rakes is the lowering of the rakes to the bottom of the intake with the teeth open, or parallel to the rack bars, so that the rake rides over the trash that is next to the bars. In most instances the rake is so unbalanced that it opens of its own weight. On reaching the bottom, the rake is closed by mechanical means so that the rake teeth project into the rack-bar spaces. The rake is then hoisted, thus bringing the accumulated trash along with it.

The rake teeth should project into the rack-bar spaces a short distance of about one inch for effective cleaning but must be kept clear of the horizontal rack-bar supports. One type of rake is held back its proper distance from the rack by broad-rimmed wheels on the ends of the rake frame, which wheels bear on the edges of the rack bars when lowering or hoisting. As the rake is dependent on its weight for keeping the wheels in contact with the rack surface, it is necessary that the racks be set sloping. As the rollers are not run in fixed guides, the width of this type of rake may be made less than the width of intake bay on which it operates.

Another type of rake is operated in the same manner as the one just described, but the rake-frame rollers run in fixed guides. The guides may be fastened to the rack structure, or as is more often done, they may be embedded in the concrete piers adjacent to each side of the intake. The guides prevent lateral movement of the rake and also hold the rake its proper distance from the rack bars. Such a rake is shown in Fig. 3. When a rake of this type is used to clean two or more bays of racks, it is necessary that the guides be spaced the same distance apart in each bay.

The mechanical hoist most commonly used to operate the rake is an individual hoist connected by cables to the rake and used for this operation alone. Figs. 2 and 3 show this type of hoist. In a few instances, the rake is operated by an independent hoist such as on gantry or rotary cranes that are used for other operations around the plant. Fig. 4 shows a locomotive crane being used to operate a rake and Fig. 5 is a close-up view of the rake and frame showing the lowering and hoisting cables attached.

The individual rake hoist almost always proves the most economical to use, as this hoist is designed especially for use with the individual rake that it is to operate. The hoist consists in general of three drums on a shaft that is rotated by a motor through suitable reduction gearing. Two of the drums on which are wound the hoisting cables are keyed to the shaft while the third drum on which is wound the lowering cable is relatively movable. If the rake is designed to open of its own weight, this lowering drum allows the main rake frame to lower slightly while the rake proper is held stationary relative to its frame and thus permits the rake teeth to open. Upon hoisting the rake, the lowering drum is allowed to lag only a part turn from the hoisting drums so as to wind the lowering cable without putting any tension on it.

The hoist is equipped with brakes for holding the rake in the raised position and for governing the speed of lowering. The type of brakes used on rakes not requiring heavy duty are usually of the hand-operated band type. Others use solenoid or thruster types on the motor-shaft extension.

Another type of mechanical rake that has recently been put

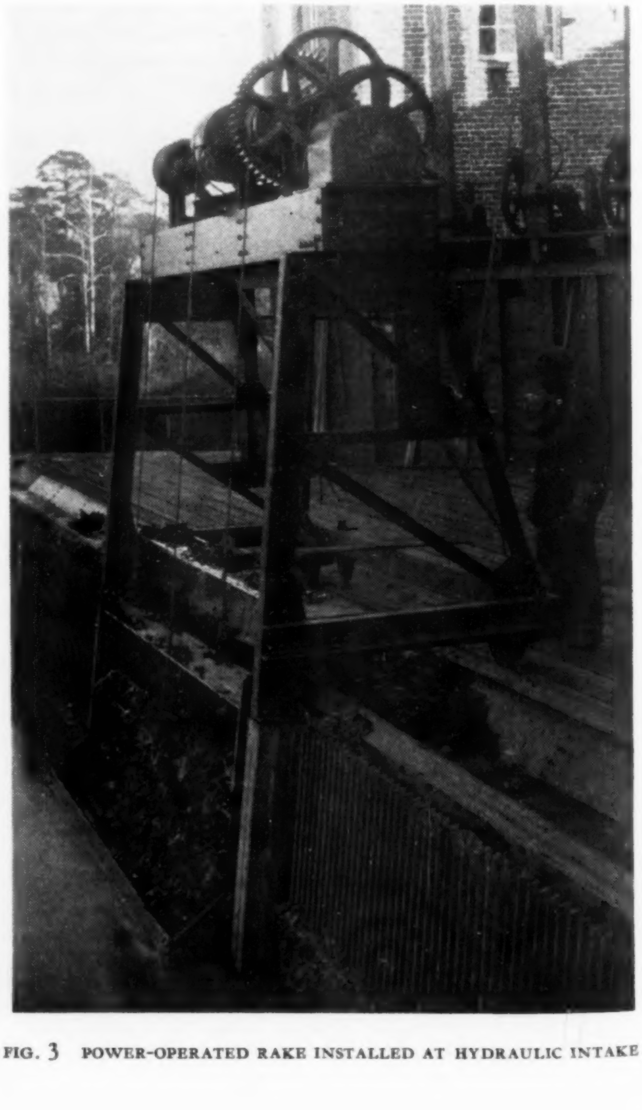


FIG. 3 POWER-OPERATED RAKE INSTALLED AT HYDRAULIC INTAKE

into service operates on the principle described heretofore, except that the rake proper is so balanced that it closes of its own weight. Tension is required in the lowering cable to hold the rake open, and this cable is also used to dump the rake of trash when hoisted.

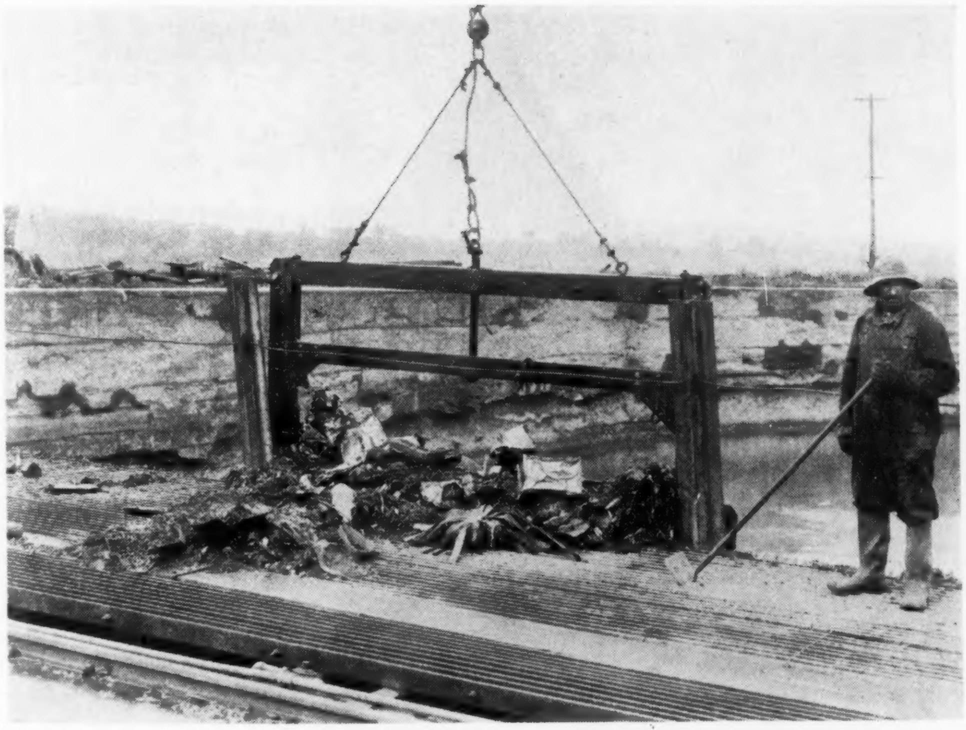


FIG. 5 CLOSE-UP VIEW OF RAKE SHOWN IN FIG. 4

CONSTRUCTION

Power-operated rakes must of necessity be built to withstand severe service. Not only must they handle small trash, but should be capable of removing logs of reasonable size or other debris that may cover the intake. Fig. 6 shows a rake equipped with detachable log hooks that is designed to lift submerged logs up to 18 in. in diameter. At a few intakes that are troubled with silt piling up at the bottom of the intake, a "digging" rake is used to keep the channel clear of silt. However, any rake will loosen silt so that it will wash on through the intake during the normal operation of the rake described heretofore. At some plants where surface ice piles up on the rack bars the rake is dropped through the ice to break it and then used to remove the ice in the same manner as removing trash. The illustrations presented herein give some idea of the type of trash a rake must handle.

The hoist machinery must not only be capable of hoisting the rake with the maximum load of trash that it can handle, but must withstand shock that occurs during sudden stopping of the rake when lowering. The gears and hoisting cable should take the load of the driving motor plus any overload the motor may exert without undue strain on any of the parts. The capacity of the motor is determined from the weight of the rake plus an assumed load of trash, the hoisting speed of the rake, and the efficiency of the reduction gearing in the hoist mechanism. The motor must have ample capacity to hoist a loaded rake, but care should be taken not to use too large a motor that would cause damage to the rake parts in case the rake is jammed while being hoisted. Some rakes are proportioned so that, if the points of the teeth strike an obstruction, the rake will automatically open before the pull on the hoisting cables becomes excessive.

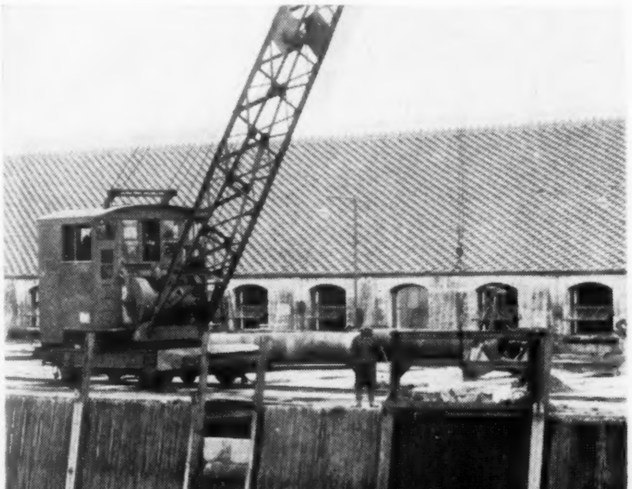


FIG. 4 RAKE OPERATED BY LOCOMOTIVE CRANE AT CANAL INTAKE

Practically all power-operated rakes are operated by an electric motor which necessitates protection of the electrical equipment against weather, as most rakes are installed out of doors. A weatherproof motor is sometimes used, although more often an open-type motor protected by a sheet-steel cover is used. Electrical fittings and conduits likewise must be protected from the weather. At a few installations where extremely high water would cover the hoist, the motor is mounted so as to be readily removable, while starters, switches, and other electrical fittings are made watertight.

Hoist gearing and cable drums are also usually provided with covers for protection as well as for safety. Instead of individual covers for the hoist parts, a few installations have one cover over the entire hoist mechanism. This cover provides the maximum of protection and usually the best in appearance although usually more expensive than the separate covers.

The hoisting drums must be placed above the point of trash discharge from the rake, consequently the rake guides must extend above the intake deck. These guide extensions form a part of the structure on which the hoist is mounted. A structural-steel frame is the most common type of hoist support in use. When a rake is used over only one bay, the hoist support is easily fastened to the intake decking or the powerhouse wall, whichever presents the more convenient and economical

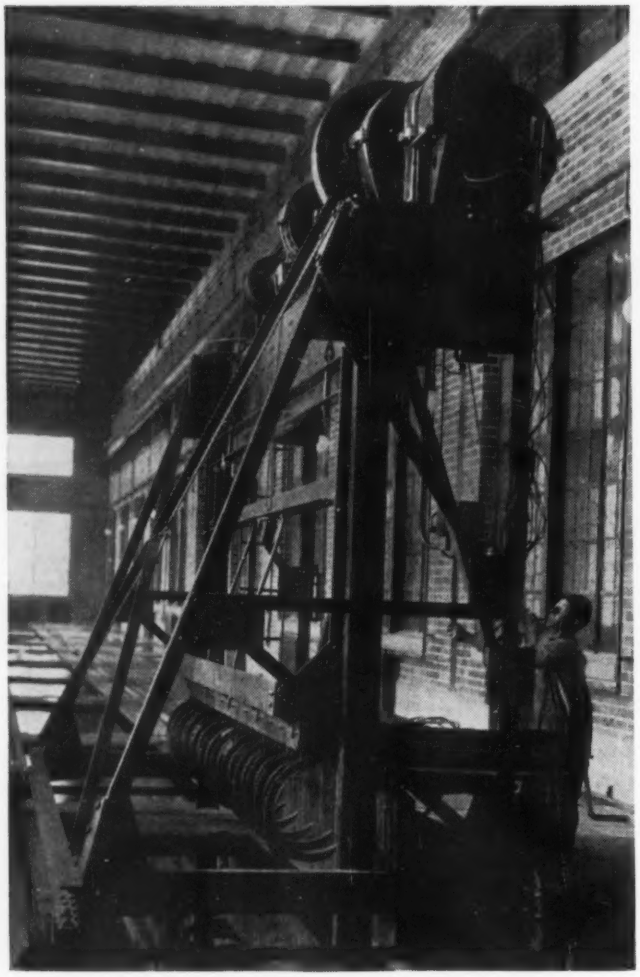


FIG. 6 RAKE WITH LOG HOOKS ATTACHED

method of fastening. If more than one bay is to be cleaned, and these bays lie in a straight line, it is usually more economical to mount the hoist on a traveling carriage so that one rake and hoist is used for a multiple number of bays. The hoist support or traveling carriage travels on rail laid on the intake deck. It is then necessary to align the rake with the bay it is to clean and latch the carriage in this position. In case the overturning moments exerted by a loaded rake onto the carriage exceed the resisting moments against overturning, rail clamps or counterweights are used in a similar manner to those used on locomotive cranes. The rake hoist is sometimes combined with a stop log or head-gate hoist.

There are many hydraulic intakes consisting of a multiple number of bays in line on which are installed individual rakes and hoists for cleaning. Individual rakes are made necessary by uneven width of bays or more often by the lack of room to install rails for a traveling type of hoist carriage. In such installations it is sometimes found more economical to install a multiple hoist. Eack rake has its own hoist equipped with a clutch and brakes, but driven through a jackshaft by a motor common to all hoists. A multiple hoist for four bays is being successfully operated at one plant.

TRASH DISPOSAL

Cleaning the rake of trash is accomplished by means of hand raking in most installations although some rakes employ mechanical means for dumping the trash. One type of rake dumps its trash load by pulling the rake open when in its raised position, thus dumping the trash onto an apron fastened to the carriage. A mechanical cleaning device that sweeps the rake has been successfully used but it is not justified in most installations as the one operator required to operate the rake can also clean the rake by hand very readily. The trash is removed from the headworks by carting away or sluicing. Some few plants provide mechanically pulled trash cars that receive the trash from the rake and haul it away.

CONCLUSIONS

That the power-operated rake is a money- and time-saving device is proved by the number of installations made at intakes to hydraulic turbines, condenser pumps, canal headworks, and other hydraulic intakes. One power company reports the effect of mechanical raking of the intakes at one of its plants. The report is shown in graphical form in Fig. 7. The load curve of November 28 represents a very good, clear-water operating condition. There was no trash running and all nine wheels in the plant were in operation. The load curve of November 29 shows the first day of that month when trash began to run. The load in each wheel began to drop until one wheel had to be shut down because the intake racks were completely choked with trash.

The load curve of December 28 shows operation after a power-operated rake was installed. On this day, the company reports that trash was running in a manner similar to that of November 29. One rake was installed here, and it was moved from one bay to another as fast as each was cleaned. The total output for the three days shown was as follows:

Nov. 28	102,490 kwhr
Nov. 29	43,040 kwhr
Dec. 28	115,279 kwhr

The daily power output of December 28 shows a gain over that

(Continued on page 277)

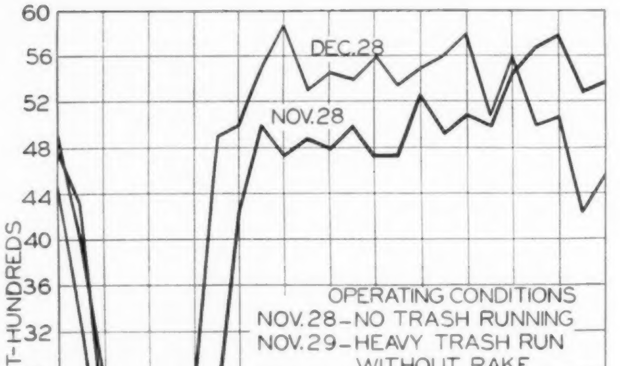


FIG. 7 CHART SHOWING LOAD CURVE AT HYDROELECTRIC PLANT ON THREE DIFFERENT DAYS

RUBBER SPRINGS *Under* COMPRESSION LOADING

By J. F. DOWNIE SMITH

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IT IS common practice when using rubber pads in shear to subject the rubber to compression simultaneously. The value of the compression is ordinarily from 5 to 10 per cent of the free thickness of the rubber, and before shear stress is applied it is customary to have a shape something like that shown in Fig. 1. Depending upon conditions, the angle θ would vary with the shear load. A question which might arise in the designer's mind is: "With varying angles of θ, what would be the effect on the compression-load-deflection curve?" This can be investigated in several different manners. One would be to vary the angle θ, always maintaining the same length, width, and height of the piece. It is clear that with one length, one width, and one height of the rubber, a piece with the angle θ greater than zero would give greater deflection under a compression load of a certain amount than a rectangular block with the same dimensions. In the experiment performed here, this particular method was not adopted merely because it was inconvenient. The system used was to maintain a constant width and height, starting with a rectangular block of a definite length. From this block duplicate wedge-shaped sections were cut from each end, thus decreasing the length, and the load-deflection curve was again obtained. The experiment was repeated for several different angles of θ up to 30 deg. After the block with this angle removed had been tested, the angle was decreased by cutting wedges in the reverse manner from the piece until the angle was reduced to zero. The second set of curves obtained with various angles is shown in Fig. 2.

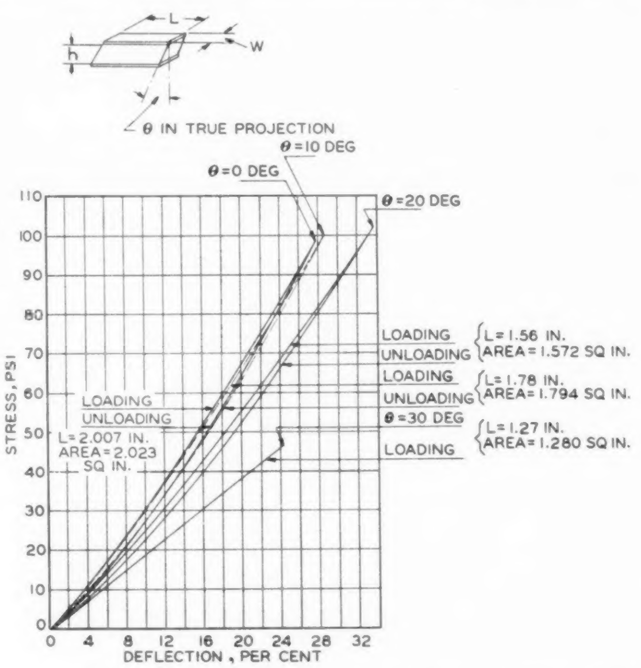

FIG. 1 COMPRESSION LOADING OF RECTANGULAR RUBBER SLAB WITH ANGLE θ INCREASING FROM ZERO TO 30 DEG

(W = 1.008 in. and h = 1.031 in. in all cases. 36 durometer hardness.)

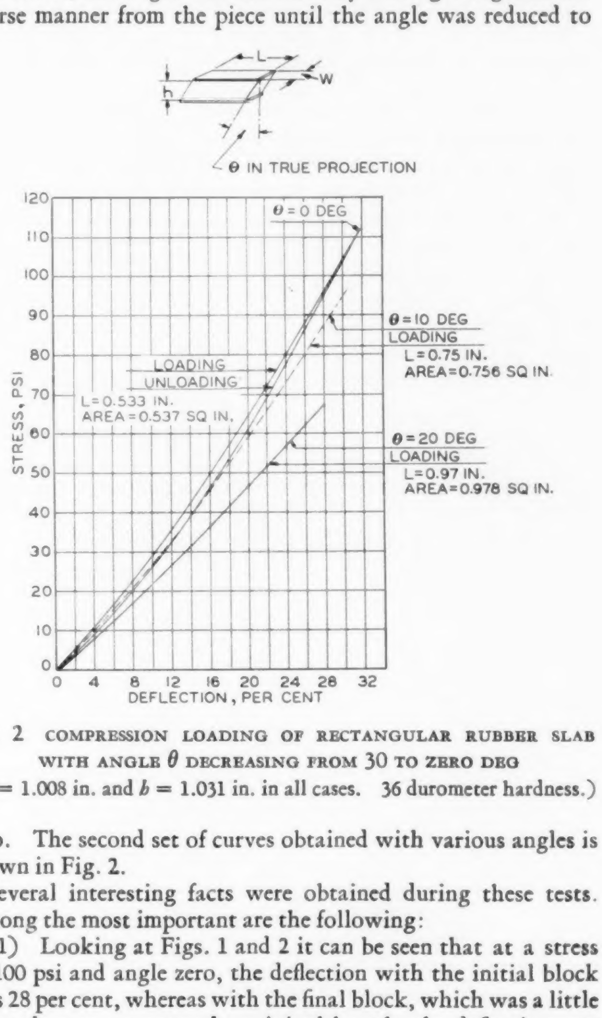

FIG. 2 COMPRESSION LOADING OF RECTANGULAR RUBBER SLAB WITH ANGLE θ DECREASING FROM 30 TO ZERO DEG

(W = 1.008 in. and h = 1.031 in. in all cases. 36 durometer hardness.)

Several interesting facts were obtained during these tests. Among the most important are the following:

(1) Looking at Figs. 1 and 2 it can be seen that at a stress of 100 psi and angle zero, the deflection with the initial block was 28 per cent, whereas with the final block, which was a little more than one quarter the original length, the deflection was 29 per cent. Thus the influence of length over this range was not great. Such close agreement is not obtained with angles of θ greater than zero. For example, with θ = 20 deg and stress of 60 psi, the deflection with the larger block is about 21.5 per cent, whereas with the smaller one it is about 25 per cent.

(2) A second important point involves the first statement that no great change in deflection based on a definite compressive stress applied to the plates takes place over a wide range in length. From Fig. 1 it can be seen that a shear pad, starting with an angle θ = 30 deg and a compression of 20 per cent, would have a lateral compressive force of 38 psi. When this

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pad is loaded in shear, however, until the angle $\theta = 0$ deg for the same compressive deflection the compressive stress is now 67 psi, or an increase of 76 per cent over that originally applied. For still larger initial angles of θ than 30 deg (and 45 deg is common in industry) it would be expected that still greater compressive stresses would be encountered. This naturally is of importance when designing the housings for the shear pads.

The author realizes that this conclusion is based on indirect readings, and that verification by direct measurement would be desirable. Such measurements would involve the determination of compressive stresses as shear loads are increased from 0 to maximum.

A possible explanation of this phenomenon can be obtained from Fig. 3. For this argument we can consider that the rubber consists of an infinite number of rubber columns, each one alike and all parallel to column A. As the angle θ is decreased with constant height h, the length of each element A decreases, so that the compressive force necessary to maintain h is increased.

In contrast to this effect we have the following rather well-known result: If a double shear pad is loaded centrally with small initial lateral compression (see Fig. 4), then under full load the slabs tend to leave the supporting walls at the top, indicating a decrease in compressive force at this point as the shear stress increases. This can be understood from Fig. 4. As the angle θ decreases, diagonal A decreases in length, thus creating compression at X, but diagonal B increases in length, causing tension at Y. If the previous conclusion regarding the increase in compressive stress is correct, it must be that the increase in compression at the bottom of the shear pads is much

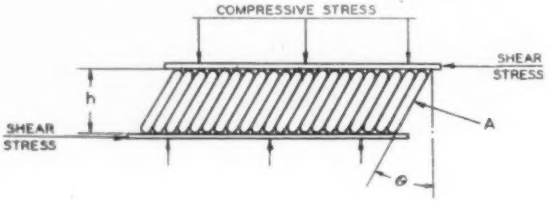

FIG. 3

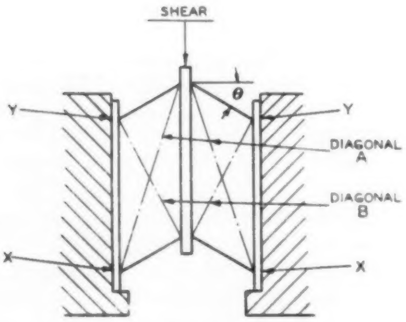

FIG. 4

greater than would be expected at first glance. Further experimentation on this particular subject might yield interesting results.

(3) The effect of increasing angles θ on the compressive stress-strain curves is not linear. Small angles play little part whereas larger angles have more effect than would be obtained from direct proportion to the smaller angles.

(4) If the effective area is considered to be $W(L - h \tan \theta)$, then the curves all come much closer together, showing that the end piece of length $h \tan \theta$ plays little part in the resistance to compression.

RECTANGULAR PADS WITH HOLES

It is common commercial practice, where compression pads are to be used for relatively large deflections, to have the pads perforated. Such a pad is shown in Fig. 5. A single slab of this construction was tested in the laboratories of the B. F. Goodrich Company and the curve obtained experimentally is dashed in Fig. 5. Upon receiving those slabs, seven were

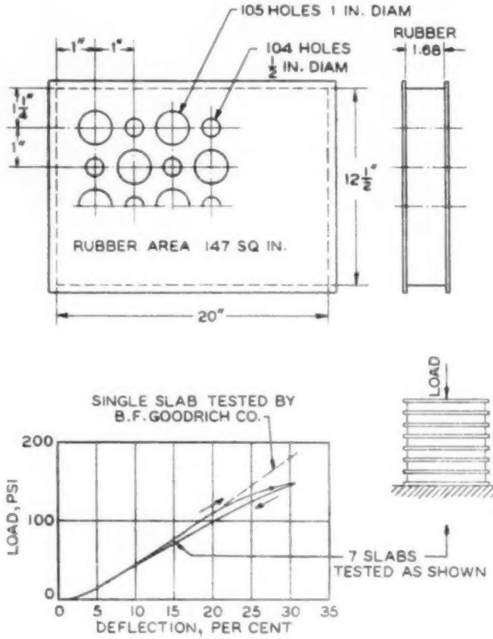

FIG. 5 COMPRESSION LOADING, B. F. GOODRICH RUBBER, 38 DUROMETER, COMPOUND 9250

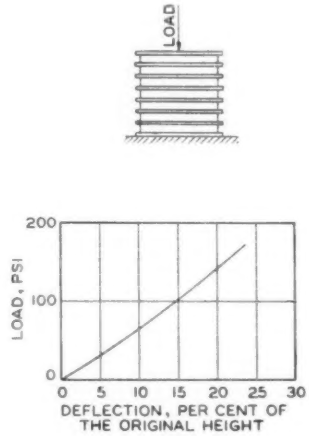

FIG. 6 COMPRESSION LOADING OF A SET OF 7 RUBBER SLABS, B. F. GOODRICH RUBBER, 38 DUROMETER, COMPOUND 9250

(Dimensions, $20 \times 12^1/_2 \times 1.68$ in.; 105 holes 1 in. diam; 104 holes $^1/_2$ in. diam; four $^5/_8$-in-diam guide pins to prevent buckling of the slabs.)

mounted in series in the laboratories of the Edw. G. Budd Mfg. Co. and the load-deflection curve again obtained. It will be seen from Fig. 5 that up to about 20 per cent deflection, the curve for the single slab agrees with that for the seven slabs. This, of course, is to be expected. Upon still further increase in load, however, the deflection of the seven increased more rapidly than did the single one. The reason for this increase was found during test and can be definitely given as instability. To check this conclusion the same slabs were mounted with

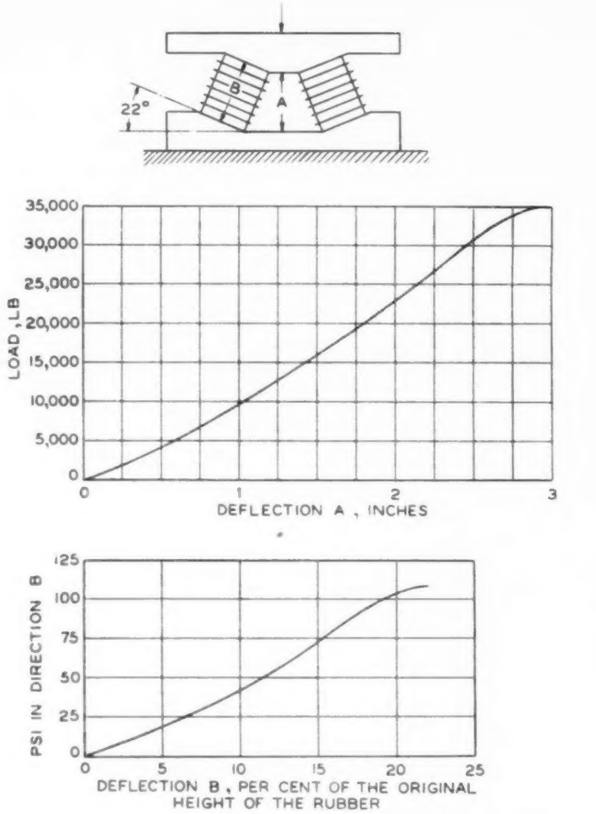

FIG. 7 COMPRESSION LOADING OF A SET OF 14 RUBBER SLABS, B. F. GOODRICH RUBBER, 38 DUROMETER, COMPOUND 9250

(Dimensions, 20 × 12$^1/_2$ × 1.68 in.; 105 holes 1 in. diam; 104 holes $^1/_2$ in. diam in each slab.)

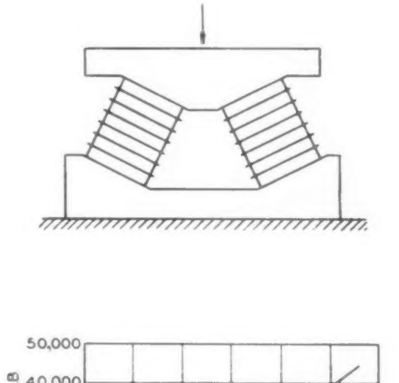

FIG. 8 COMPRESSION LOADING OF A SET OF 14 RUBBER SLABS, B. F. GOODRICH RUBBER, 38 DUROMETER, COMPOUND 9250

(Dimensions, 20 × 12$^1/_2$ × 1.68 in.; 105 holes 1 in. diam; 104 holes $^1/_2$ in. diam in each slab; four guide pins $^5/_8$ in. diam in each set of slabs.)

four guide pins to prevent side movement of any slab, and curves again obtained. Fig. 6 shows that the instability was not evident even up to 24 per cent deflection.

Thus care must be taken where large deflections are to be obtained either to keep the total height of the slabs small compared with the linear dimensions of the loaded area or to provide a guide for the slabs to improve stability.

These slabs were then placed in two groups of seven each at an angle of 22 deg to the horizontal, as shown in Fig. 7. In this figure also it can be seen that after some 18 per cent deflection, instability crept in. When guide pins were placed in four of the holes and the experiments repeated, this instability had not appeared up to deflections of 24 per cent, as can be seen in Fig. 8.

TORSION BUSHINGS

Torsion rubber bushings are becoming quite popular and occasionally they are used where no provision is made for insuring concentricity. Thus a torque arm may be applied to either the inner or outer metallic bushing and unless this torque arm is equalized, a load can be applied to the rubber perpendicular to the axis. In order to find the radial deflections to be expected with a particular sample of rubber bushing, the experiment shown in Fig. 9 was performed. This consisted in loading the inner cylinder relative to the outer while maintaining the outer one in a fixed position. With such loading conditions the stresses in the rubber are of various types. At the bottom the stress is compression; at the top, tension; at the sides, shear; and at other points, combinations of those would be expected. Unfortunately, the rigidity of rubber under all three conditions would be extremely difficult to calculate. In

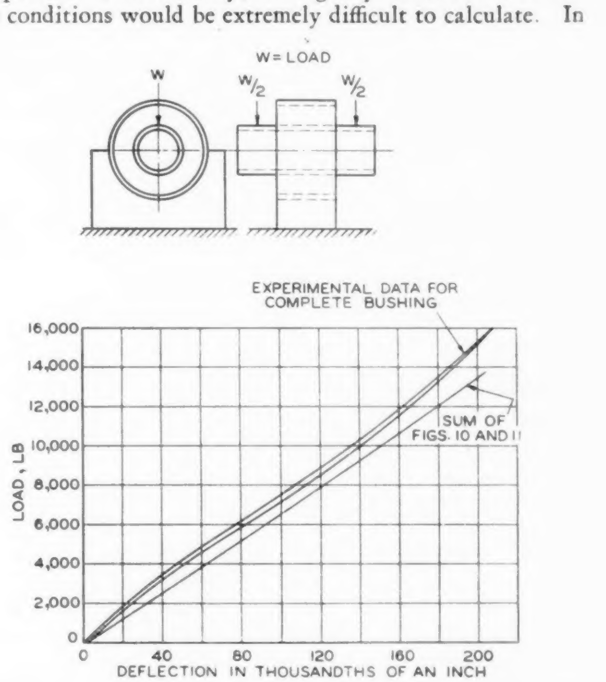

FIG. 9 LOADING OF RUBBER BUSHING 90 DEG TO AXIS OF BUSHING

(Dimensions of rubber; 4 in. inside diam; 5.75 in. outside diam; 5 in. long; 45 durometer rubber.)

order to get a rough figure for the relative importance of the various items, this bushing was cut in two and the lower half loaded in compression as shown in Fig. 10. The bushing was then turned upside down and this same half bushing loaded in tension as shown in Fig. 11. For a given deflection, the sum of the half bushing loaded in compression and the half bushing loaded in shear was obtained and a curve plotted in Fig. 9. It will be seen that this does not quite check the original curve so that the two cannot be considered independently.

In Fig. 9 it can be seen that, over most of the range, the slopes of the curves are quite similar. In order to determine roughly how effective each part of the bushing was in with-

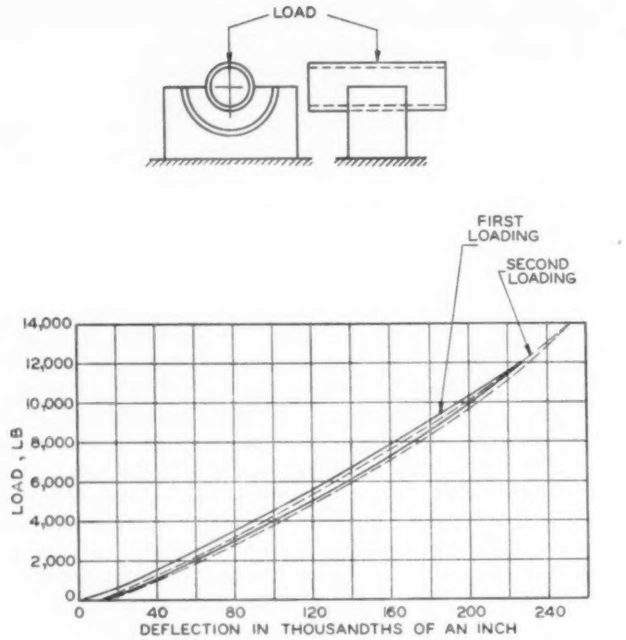

FIG. 10 LOADING OF ONE HALF OF A RUBBER BUSHING WITH RUBBER IN COMPRESSION

(Dimensions: 4 in. inside diam; 5.75 in. outside diam; 5 in. long; 45 durometer rubber.)

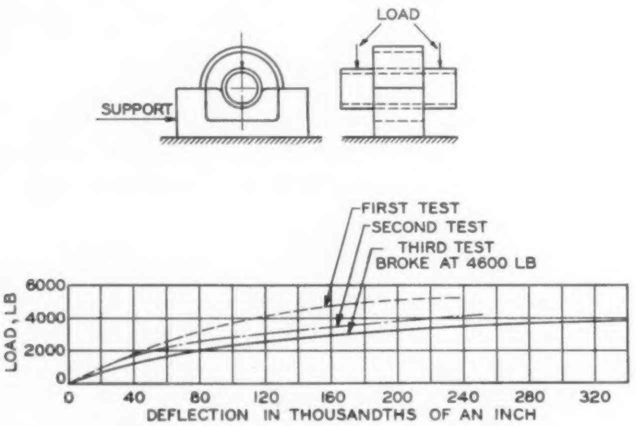

FIG. 11 LOADING OF ONE HALF OF A RUBBER BUSHING WITH RUBBER IN TENSION

(Dimensions: 4 in. inside diam; 5.75 in. outside diam; 5 in. long; 45 durometer rubber.)

standing tension and compression, the bushing was cut still further, as shown in Figs. 12 and 13. It will be noticed that under a static deflection of 0.200 in. the half cylinder maintained a compression load of about 10,000 lb (Fig. 10). When 15 deg had been removed from each side (Fig. 12) a deflection of 0.200 in. was obtained with a load of 4800 lb, although only one sixth of the rubber had been removed from the half cylinder.

Comparing Figs. 11 and 12 for tension values, it will be seen that for the same rubber reduction of one sixth at 0.100 in. deflection the load is reduced from approximately 2400 lb to 1450 lb.

Thus the influence on resistance to radial movement of the side parts of the bushing is quite appreciable.

Continuing the test in tension the data in Fig. 13 were obtained. Notice that for 0.100 in. deflection a load of about 1050 lb is carried, although only one third of the half bushing has been cut away. Unfortunately, this part of the bushing was damaged at the completion of this test so that the compression curve was not obtainable.

In Fig. 14 data on radial movement have been plotted for a bushing where the length decreased with increase in radius.

Frequently bushings of this general type are loaded nonsymmetrically, and one cylinder is twisted relative to the other in the manner shown in Fig. 15. This bushing is the same one shown in Fig. 9.

Every test described in this paper was performed with rubber vulcanized to metal.

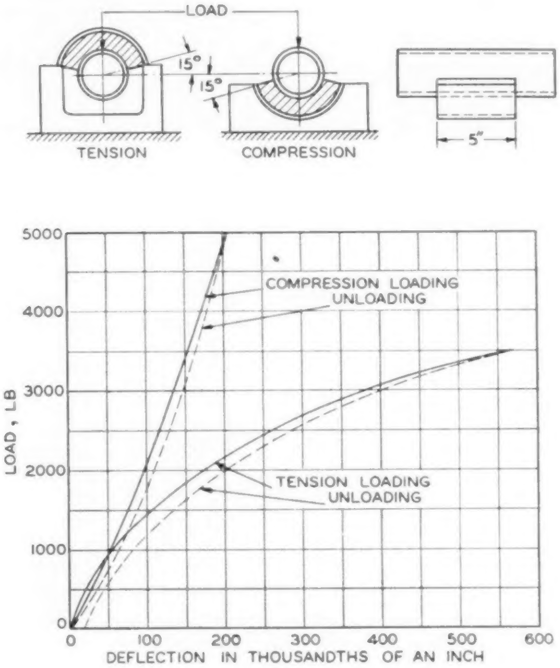

FIG. 12 LOADING OF A SECTION OF A RUBBER BUSHING IN TENSION AND COMPRESSION

(Dimensions: 4 in. inside diam; 5.75 in. outside diam; 5 in. long; 45 durometer rubber.)

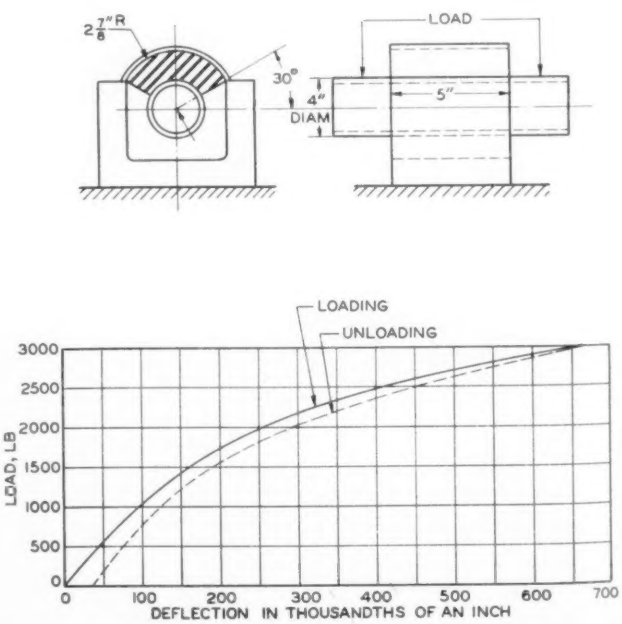

FIG. 13 LOADING OF A SECTION OF A RUBBER BUSHING IN TENSION

(Dimensions: 4 in. inside diam; 5.75 in. outside diam; 5 in. long; 45 durometer rubber.)

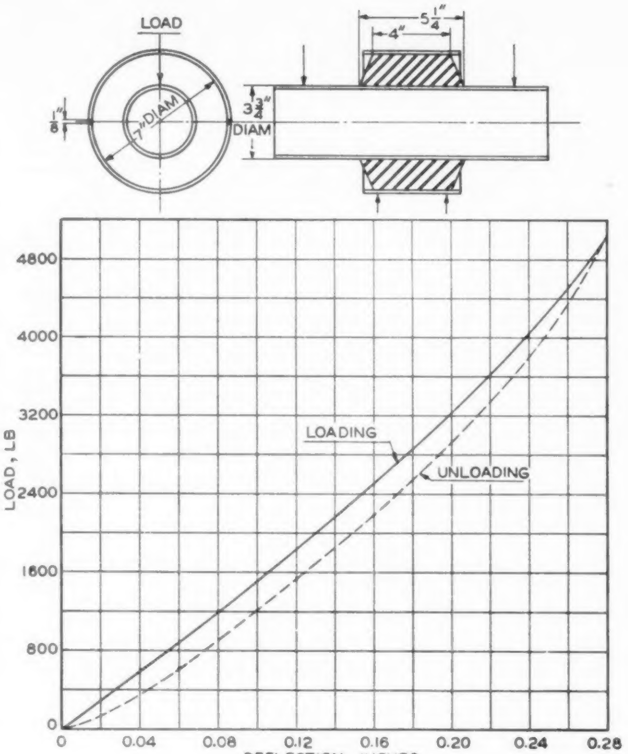

FIG. 14 LOAD-DEFLECTION CURVE OF A METAL-CLAD RUBBER BUSHING, 50 DUROMETER RUBBER

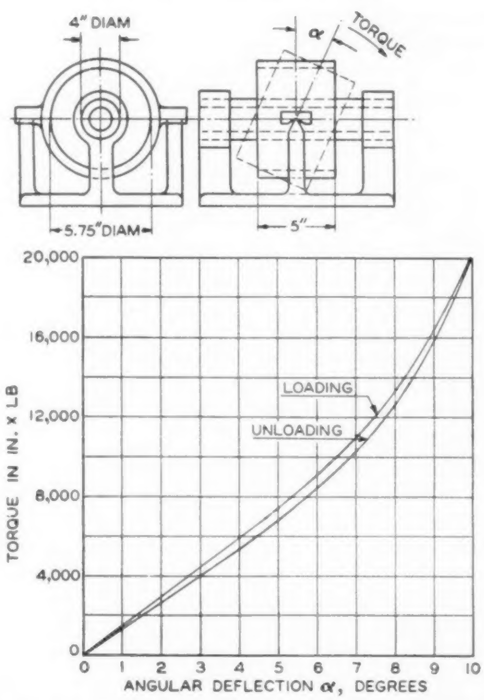

FIG. 15 DEFLECTION CURVE OF A METAL-CLAD RUBBER BUSHING TWISTED AROUND AN AXIS 90 DEG TO AXIS OF BUSHING

(Dimensions: 4 in. inside diam; 5.75 in. outside diam; 5 in. long; modulus of elasticity, 76 psi in shear, 228 psi in compression.)

ACKNOWLEDGMENTS

Some of the experimental data were obtained in the laboratories of the Edw. G. Budd Mfg. Co. by D. Birkin, R. J. Lee, and F. Heinze, and the author appreciates the cooperation of the company in this work.

Power-Operated Rakes for Hydraulic Intakes

(*Continued from page 272*)

of November 28, which increase is explained by the fact that the rake was able to dig away trash and silt that had accumulated against the bottom of the racks.

Power-operated rakes have been made in widths varying from a few feet up to 28.5 ft and designed for a travel up to 180 ft as shown in Table 1. The maximum width and travel to which a power-operated rake can be built to operate successfully depends entirely on the type of operation to which the rake will be subjected, but in general a rake should not be made wider than 16 ft, for a larger rake than this becomes unnecessarily heavy if properly designed to withstand severe service. A limit of travel of 100 ft is considered good practice, although it is seen from Table 1 that several have exceeded this limit. For these exceptionally long travels, the drums on the hoist were made unusually large as it is not desirable to have the wound cable overlap.

TABLE 1 RACK-RAKE INSTALLATION DATA

Plant	No. of bays	Rack-bar thickness, in.	Rack-bar spacing—c to c, in.	Width of rake, ft	Travel of rake, ft
All American canal headworks..........	..	3/8	2.5	16.2	45
Claytor...............	8	1/2	4.5	14.8	75
Conowingo.........	15	5/8	6	23.0	105
Cushman No. 2........	4	1/2	4	10.0	40
Diablo (outlet)........	4	1/2	4	14.0	180
Hawks Nest...........	6	5/16	3.5	18.5	58
London...............	6	3/8	4	20.0	30
Madden Dam..........	5	3/4	3.5	16.0	153
Marmet...............	6	3/8	4	20.0	30
Norwood.............	3	3/8	3	20.0	75
Osage................	6	3/8	6	28.5	84
Safe Harbor...........	39	5/8	7	17.0	70
Spier Falls............	8	1/2	5.5	15.3	60
Wheeler..............	24 (ult)	7/8	6	18.0	76
Winfield..............	6	3/8	4	21.5	33

The proper installation of rack bars is imperative for the successful operation of the power-operated rake, a fact that must be borne in mind when building the intake whether an immediate installation of mechanical rake is contemplated or not. Rack bars must be evenly spaced and held in a straight line. The racks should extend to the top of the intake deck, or an apron must be installed so as to hold the trash on the rake between the top of the rack bars and the point of disposal of the trash. Rake guides are more easily installed during construction of the intake than after the plant is in operation, and they should be carefully set parallel to each other and the proper distance from the bars for effective use of the rake. The rake must be designed and built to withstand severe service, but must be simple in its operation to afford maximum reliability. In the operation of hydroelectric plants and pumping plants, the reliability of operation of the units depends as much on keeping intakes open as on keeping the machinery in running condition.

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ARMY MATÉRIEL INSPECTION

By R. W. CASE

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THIS address on Army matériel inspection is based upon inspection as carried out in the Ordnance Department. The inspection methods of other branches of the Army follow essentially the same principles.

Considering the many ramifications this inspection takes, I can only sketch in a general way the organization and the objectives of the system which the Ordnance Department uses. This system, incidentally, has proved satisfactory over many years of actual use, and we feel it to be a practical solution.

INDUSTRY MUST PRODUCE 95 PER CENT OF ARMY'S MATÉRIEL NEEDS

As we are all beginning to learn, war today is a very inclusive and complex business. Every person in a nation at war is really a combatant whether you want to call him a soldier or not. He must in his own way help to provide for the frontline troops. The regular Army and National Guard can train our newly enlisted men, but United States industry must provide for these men. A trained soldier without the means of transportation, protection, and fire power is certainly a very helpless individual. Our arsenals can at best furnish 5 per cent of these needs—United States industry must do the rest.

As is usual in an emergency, the bottleneck is the availability of ordnance matériel such as guns, tanks, and ammunition. As is well known, the sources of these supplies are, in the main, to be furnished by the industry of the country. In other words, approximately 95 per cent of all the arms, equipment, and other supplies needed will be furnished by the manufacturers of this country, with the help of the Ordnance Department which, with its experience, can give to industry specialized technical advice and training information. The extent to which the United States can properly defend itself will be determined today by the progress that industry makes in fulfilling these contracts. It can be seen, therefore, how very important it is that there be a close cooperation and complete understanding between the Ordnance Department and industry as a whole.

It might properly be asked, "What is the Ordnance Department doing to help in this understanding and cooperation that seem to be so valuable?" There are several ways. Ever since the last war we have had ordnance personnel in the various districts cataloging and surveying possible manufacturers of ordnance equipment. This list has been revised from time to time, and kept up to date and, now that we are in need of these supplies, we at least have an idea as to what people should be contacted. We have taken care of the basic consideration of having a good list of possible bidders for these contracts. At least we will not waste time asking a foundry, for example, to produce optical instruments.

INSPECTION A NECESSARY STEP IN PROCUREMENT

Inspection is a necessary step in the process of procurement. First must be set up the requirements. These must be stated clearly and definitely. This involves adequate specifications and drawings. Sound contractual procedure must be provided. Then follows production. Inspection must be carried on coincident with production. The broad functions of inspection are to insure that material is produced that meets the requirements of the drawings, the specifications, and the contract. The necessity for having compliance with these is self-evident when one considers that parts produced in widely separated plants must be capable of quick and accurate assembly. There must be interchangeability of parts in order to make possible rapid repair in the field. And above all there must be dependability of service. The old story of what happened for lack of a horseshoe nail. It is easy to conceive of very serious results coming from the lack of a properly fitting bolt or nut in a piece of ordnance equipment.

A word about the contracts themselves. Contracts for ordnance matériel desired are usually let by the arsenal which has had experience in producing this same matériel. Watertown Arsenal, for example, lets contracts on all A.A. and C.A.C. matériel. In that way we are reasonably sure of stating clearly and definitely to industry exactly what is wanted. In other words, we have had the experience ourselves in the manufacture of these articles and can appreciate some of the problems and questions which industry will undoubtedly encounter.

In the drawing up of specifications which constitute part of the Army contract, we call for material and practices which we *know* industry is capable of furnishing. Never is a specification drawn up without the advice of, or consultation with, representatives of manufacturers. The Ordnance Metallurgical Board, for example, is composed not only of Ordnance officers, but also of notable representatives of the steel and metals industry. We are constantly on the lookout for improvements in design which will simplify manufacture. Only in the case of extreme emergency are special or uncommon practices required.

Now, as to *drawings*, also a part of specifications, it is a fundamental principle in the Ordnance Drafting Room Regulations that wherever they can be used, only standard commercial parts will be specified. The tolerances will be kept as wide as is consistent with interchangeability and the final over-all accuracy of the weapon being designed. All drawings are checked thoroughly by an independent group of men of the inspection division. Particular attention is paid to see that the tolerances and dimensions themselves are not impracticable in the process of manufacturing.

Finally, there is another means of cooperation in the liaison between industry and the Ordnance Department. To me, it is the most important means of obtaining this end. That is the work of the *ordnance inspector* who will deal with industry from the time the contract is let until final delivery of the completed article is effected. No system of matériel procurement is effective without the safeguard of an efficient inspection service to see that the requirements of the contract, the drawings, and the specifications are complied with. This system applies with equal force to arsenal manufacture as well as to commercial procurement. No matter how expertly and carefully prepared drawings and specifications may be, they lose their effectiveness and their value unless the material as supplied conforms to their requirements. Inspection at the place and time of manufacture is desirable. In fact, the secret of satisfactory ordnance production is well-informed and effective inspection.

An active inspection department is not only necessary for quality control, but is the best assurance for production efficiency. It is also in the best position to note and suggest im-

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provements. The attitude of the inspection department should be one of complete cooperation. Trained ordnance inspectors can and are very helpful to manufacturers. In deciding questions of a minor nature which arise the inspector must use good judgment and be neither too rigid nor too lenient in his interpretations. An inexperienced inspector can certainly bog down the procurement program, while on the other hand a well-qualified inspector can help the manufacturer considerably in his production.

ORDNANCE INSPECTION ORGANIZATION

In order to clarify the position of ordnance inspection, I should like to explain the ordnance inspection organization. Essentially, because of the experience gained in the last war where a highly centralized organization failed to function smoothly, the principle of *decentralization* was adopted. The country now is divided geographically into Ordnance Districts. The basic object of these districts is war planning for procurement in peacetime and actual procurement in war. In the procurement of ordnance matériel, inspection is one of the most important district functions. There are 13 of these Ordnance Districts. The commanding general of the contracting arsenal, however, has the final decision on the acceptability of the matériel to be sent to his arsenal. In each arsenal there is an inspection organization having an ordnance officer at the head, and trained civilian inspectors under him. In the districts a similar organization exists.

CHARACTERISTICS OF AN INSPECTOR

I would like to cover some of the characteristics which are important qualifications of an inspector. The basic qualifications, of course, are proper training and knowledge of inspection work. In my opinion, here are some of the other qualities that a good inspector should have:

1 Outstanding loyalty to the country and integrity which is above reproach.

2 A knowledge of discipline, preferably as a result of service training.

3 Knowledge of men plus some experience in handling skilled labor.

4 Metallurgical-mindedness; but of even greater importance is that he be endowed with an awareness of the simple principles of science.

5 A sense of proportion, sound judgment, and lots of common sense. If he doesn't possess this last virtue, we don't want him regardless of his skill and experience.

As is to be expected, whenever an expansion such as we now are facing occurs, there is the problem of filling the personnel requirements. To keep the system functioning properly it is necessary to obtain men and train them. It is necessary, too, to include in this training program a large number of reserve officers to supplement the regular force.

The typical civilian inspector with whom one generally has contact is a man approximately 35 years old who has been a machinist and has had probably one to two years of college work. In addition to this background, he has been trained at the arsenal for a period of two or three months. If he is assigned to a manufacturer who is making antiaircraft carriages, for example, it is very likely that this inspector has had a course of instruction at Watertown Arsenal.

The course of instruction lasts for roughly two or three months of intensive training in all phases of ordnance inspection. In the course at Watertown Arsenal, for example, inspectors have studied physical testing, macroetch, X-ray technique, magnaflux technique, and dimensional inspection procedure on ordnance equipment. They have also studied and observed the manufacturing processes used at the arsenal. They know the general requirements which must be met by the finished product. They have also benefited by contact with one of the best research laboratories of its kind in the country.

Certain inspectors are trained as welding specialists in order that they may qualify manufacturers' welders, and also intelligently read X-ray films; others as macro examiners.

The most important thing stressed in the school is the development of a *sense of proportion*. We insist that the student inspector be not graduated from the course unless we are fairly certain that he knows what is, and what is not, important in the inspection of ordnance matériel. We want no student to leave the school who will go out to a plant and consider himself too important, who will make arbitrary decisions, and in other ways generally harass the manufacturer.

The school staff, incidentally, is composed of individuals who have had years of experience in ordnance work, and who are very practical men.

ATTITUDE OF ORDNANCE DEPARTMENT

So much for the civilian inspectors. The officers of the inspection staff are, generally speaking, officers who have not only served with the Ordnance Department, but have served with branches for whom the Ordnance Department is making equipment. These officers know what the using service demands in the way of equipment, and help for liaison between the user, the designer, and the manufacturer. The officers are more the creators of policy with respect to certain equipment, than they are actually inspectors on the job. We believe, therefore, that we have a relatively well-balanced force of inspection personnel.

It is the aim of the Ordnance Department to make ordnance work as attractive as possible to the manufacturers and subcontractors, while securing for the government at as low cost as possible material and equipment fully meeting their requirement. It is vital that we do everything possible to speed up delivery so as to get the greatest amount of acceptable matériel in the shortest possible time. To that end, whenever practicable, the department will furnish actual samples of material to be manufactured. It permits, and in fact encourages, visits from factory representatives to the arsenals for the purpose of studying the arsenals' methods of manufacture of these same articles. It will give help and advice in getting operations started. We are not reluctant, in any way whatsoever, to send our officers and trained technicians to the new manufacturers in an effort to get them organized and started on the road to production. The Department furnishes all inspection measuring tools and gages which will be needed by the ordnance inspector during the entire life of the contract. The Ordnance Department believes that it goes more than halfway to help the manufacturer produce what is desired. What we ask of the manufacturer is only that he realize that he is bound by the contract, the drawings, and the specifications in that order. We also ask that for the sake of expediting manufacture he provide for a reasonable inspection of his own products prior to proffering them for ordnance acceptance. It is impracticable for ordnance inspectors in many cases to make 100 per cent inspection of all articles. The importance, therefore, of thorough company inspection is obvious.

INSPECTION FOR SAFETY OF PRIME IMPORTANCE

Inspection for safety is of prime importance. This, of course, involves the questions of dependability and performance in service. The material must conform to requirements to be safe in the field.

If I may digress for a moment, in the last war there was as

much as 10 per cent premature bursts of shell in the field. At one time when there were approximately 6000 guns on the French line, they had 750 premature explosions which could be directly traceable to poor quality.

SOME ROUTINE INSPECTION PRACTICES

It might be well at this point to describe briefly some of the routine practices in ordnance inspection. In general, these practices are identical with those used by all large firms. Bar stock, for example, may be subjected to chemical, physical, or macro examination, according to the dictates of the drawing and the pertinent specifications. Castings are searched thoroughly for surface cracks by means of magnaflux inspection. We know, of course, that cracks in castings are quite dangerous when these castings are used for guns which receive high shock stresses. It is purely a matter of safety to be sure there are no cracks in these castings. However, when we do find cracks, we frequently authorize a chipping out of the cracks, and welding is usually permitted. Oftentimes the finding of cracks and the diagnosis of cause leads to better methods of foundry practice. Occasionally, on a very important and very highly stressed casting, we might use X-ray examination, in order to determine unusual porosity.

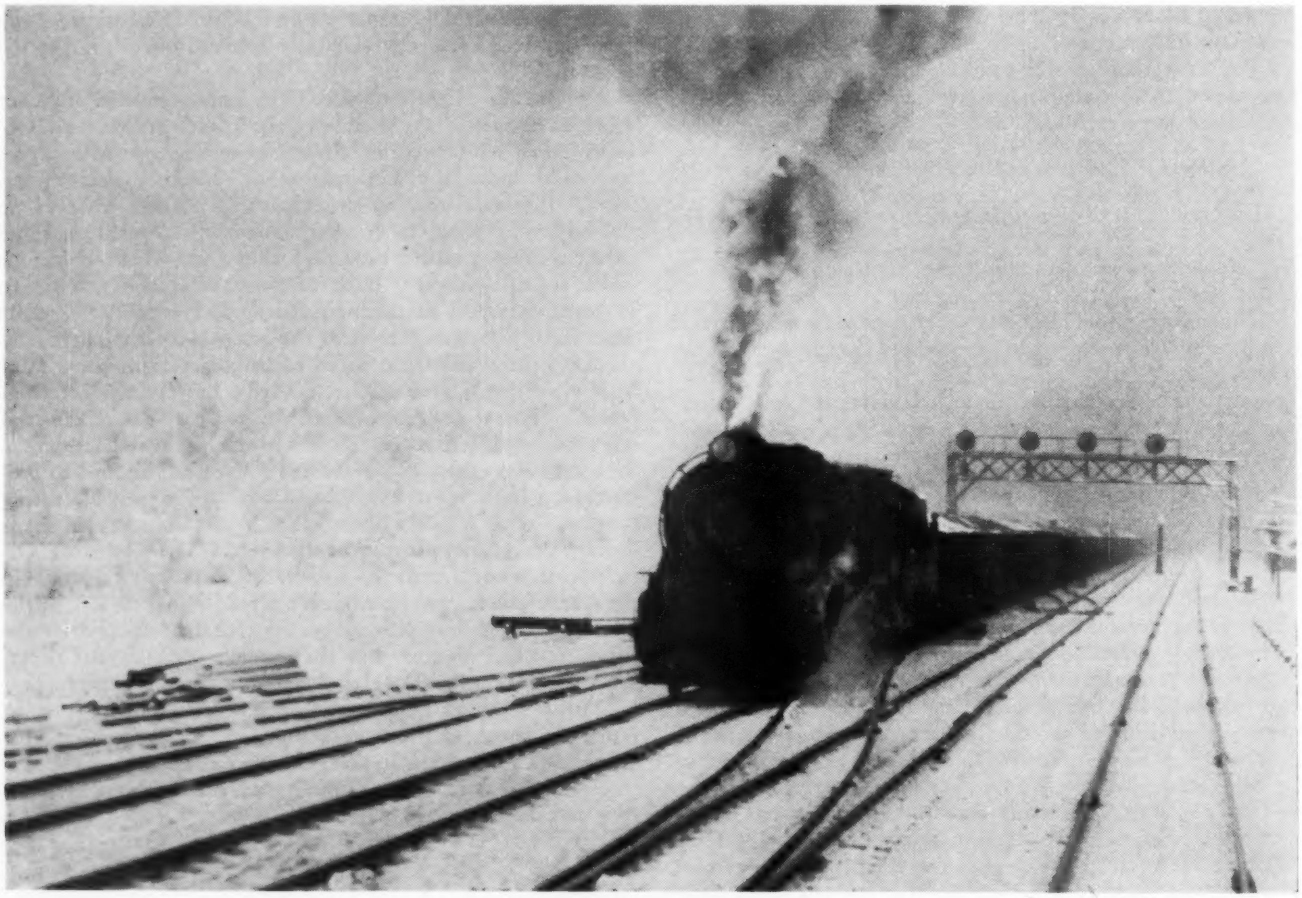
In the matter of weldments, the ordnance inspectors do not make 100 per cent inspection, and therefore, in order sufficiently to protect the interests of the government we require that all welders who are not qualified under the A.S.M.E. Boiler Code regulations qualify under regulations prescribed by the arsenal. All weldments, incidentally, are checked for cracks by means of the magnaflux method, and weldments in very highly stressed areas which are marked on the drawings are X-rayed for lack of penetration and poor fusion, and other defects.

On forgings we usually require one macroetch per heat, in addition to any other test which may be prescribed for the respective forging.

It will be seen that ordnance inspection differs very little from that required by any well-organized firm. We are particularly interested in safety, and that is one of the principal ends of all our inspection.

The Ordnance Department sincerely does not desire that any manufacturer lose money by reason of having accepted a government contract. The main objective, of course, is to obtain equipment as rapidly as possible to meet military requirements. The Ordnance Department and its inspectors are there to help produce the maximum amount of acceptable matériel, and in no sense of the word is our inspection arbitrary. Each piece that comes up for decision is considered on its own merits. We want the manufacturer to produce, and we are open-minded to suggestions and methods which will speed up this production.

Finally, may I repeat again, that more so today than ever the national defense of the United States is being determined on the production lines of the country by every executive, machinist, and in fact every worker in industry. Cooperation in this effort is greatly appreciated.



"TONNAGE FREIGHT"

(Photograph taken by W. L. Betts and shown at the Fifth Annual Exhibit held during the A.S.M.E. Annual Meeting, Dec. 2–6, 1940, New York, N. Y.)

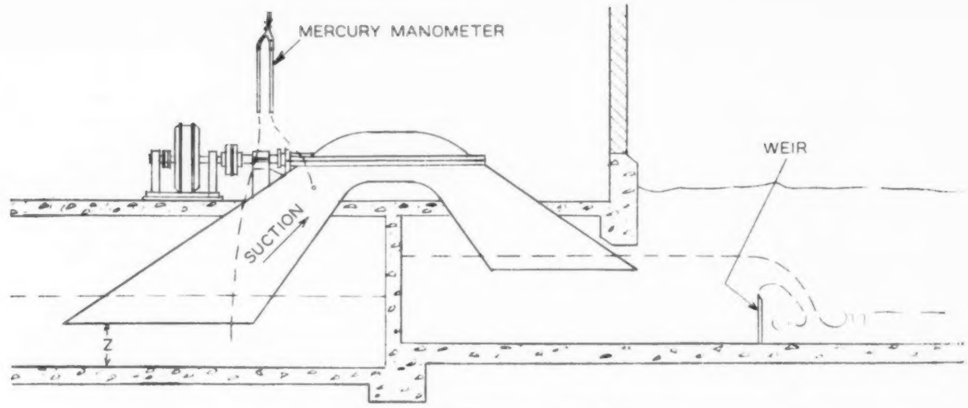


FIG. 1 EARLY TYPE OF INTAKE METER
(A coefficient of 0.93 was obtained on test. Diameter of meter throat, 54 in. Proximity of floor at *Z* accounts for low value.)

THE ANNIS METER

Instrument for Measuring Flow at Intake End of Closed Conduits

By M. B. MACNEILLE[1] and RUSSELL K. ANNIS[2]

CONSIDERING the fact that so many accurate and well-tried flowmeters are already in general use, it seems fitting to explain first the reason for developing yet another type. This can probably be best understood from an account of the necessity which prompted the invention of this particular meter.

The problem first arose in connection with measuring the rate of flow in propeller pumps such as that shown in Fig. 1. These propeller pumps had very short suction and discharge pipes, consisting only of cone-shaped conduits bolted directly to the suction and discharge flanges of the pump. This arrangement did not allow sufficient distance for the installation of a venturi meter, which in any event would have been comparatively expensive, as these pumps were quite large in size. Current meters had been considered but were not used because of the irregular shape of the channels. Pitot tubes were used on a number of occasions, and were moderately satisfactory, but the accuracy was not great on account of the irregularity of the readings, and they required too much time for the traversing of a large pipe. Weirs were also tried, but they are too costly, especially when used only once on location and then removed. The salt-water method and the Gibson method were considered but both of these methods require long pipes and for this reason were not usable.

DEVELOPMENT OF THE FIRST INTAKE METER

The first intake meter was therefore improvised by using the suction cone of the propeller pump, as shown in Fig. 1. The simplicity of the intake meter can be seen by comparing it to a venturi tube. Since the suction conduit of the pump has convergent flow exactly the same as a venturi tube, it is obvious that the same transformations of energy occur. There is, however, no straight pipe leading to the intake meter, such as required by a venturi tube. The manometer hose which, in the case of a venturi tube is connected into the upstream cylindrical portion, is simply submerged in the open channel. This acts as a balance tube. Its purpose is explained later in the paper. The throat section at the flange of the pump, in Fig. 1, acts in a manner similar to the throat of a venturi tube.

In some instances a piezometer ring has been used at the throat, and in others just a single side hole. Also, it has been found to be immaterial whether the meter connects directly into the pump suction as shown, or whether a suction pipe is used between the meter and the pump. With the intake meter, there is ordinarily no exit cone beyond the throat, because the throat is usually the same diameter as the suction pipe and no cone or diffuser is needed. There are occasions when a meter throat smaller than the suction pipe is used. Under such a condition, an exit cone is required. An exit cone, however, is known to have no influence upon the operation of a venturi meter and the question of its omission is therefore of no consequence.

It can now be seen that the intake meter has the following advantages over other fluid meters:

1 The intake meter does not require an upstream section of pipe such as required for nozzles, orifices, and venturi tubes.

2 No exit tube is required, such as is ordinarily used in connection with venturi tubes.

3 There is no loss of head, such as occurs in the downstream pipe beyond an orifice or nozzle.

4 There is no entrainment of air in the suction bay, such as occurs when testing pumps in a test tank using a weir, or an open nozzle, or orifices on the end of the discharge pipe which are allowed to discharge their jets into the open surface of the discharge bay.

5 The meter is not expensive to build or install.

6 The readings are instantaneous.

THEORY OF OPERATION

Fig. 2 is a diagrammatic view showing the principle upon

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Contributed by the Special Research Committee on Fluid Meters and presented at the Annual Meeting, New York, N. Y., December 2–6, 1940, of The American Society of Mechanical Engineers.

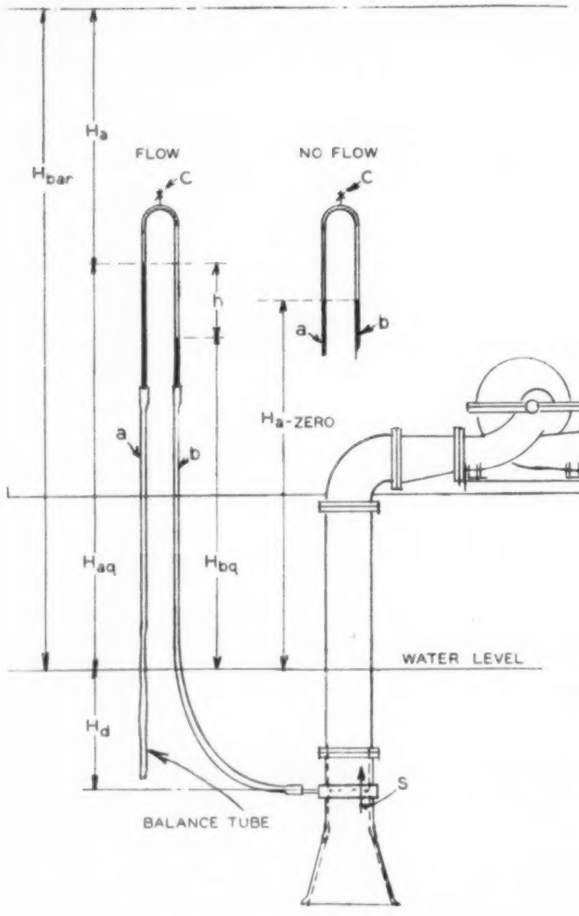

FIG. 2 DIAGRAM OF INTAKE-METER SETUP

which the theory of operation is based. The meter consists of a straight cylindrical section which is surrounded by piezometer holes exactly like the throat section of a venturi tube. Leading into this section there is a tapered section which is rounded off at the large end in order to provide an easy flow for the water entering the meter from the suction bay. A generous radius is also provided between the small end of the tapered section and the throat. Intake meters have been built up from sheet metal without these radii, however, and satisfactory results were obtained.

An inverted U-tube manometer is shown at approximately the same elevation as the pump. A rubber tube *a* is connected to one side of the manometer, and the lower end of this tube is submerged in the suction bay. Tube *b* is connected from the other side of the manometer into the piezometer throat of the intake meter. A connection *c* is made at the top of the manometer for the purpose of withdrawing a certain amount of air, thus raising the water within the manometer to an elevation which will be convenient for making readings. Let us assume first that there is no flow in the intake meter, and that an amount of air has been drawn from connection *c*, sufficient to raise the water in side *a* to a height represented by H_{a-zero} above the surface of the water in the suction bay. Since there is no flow, it follows according to Pascal's principle, that the water in side *b* will also rise to the same elevation as in side *a*. This is indicated by the dotted line. Side *a* thus acts as a balance tube to compensate for the difference between atmospheric pressure at the surface of the suction bay and the partial vacuum existing within the U-tube.

Now assume that there is a flow of V cu ft per sec into the intake meter which produces a velocity S ft per sec at the piezometer throat having a sectional area of A sq ft. Also assume that, while this flow is taking place, the amount of air withdrawn from connection *c* is sufficient to draw the water in side *a* up to any convenient height represented by H_{aq}. Thus, if H_{bar} represents the atmospheric pressure measured in feet of water above the surface of the suction bay, the absolute pressure at the water surfaces in both sides of the manometer is

$$H_a = H_{bar} - H_{aq}$$

When there is continuous flow from the suction bay into the intake meter, the total dynamic head in the suction bay and at the elevation of the piezometer, according to Bernoulli's theorem, is equal to the total dynamic head inside the intake meter, also at the elevation of the piezometer, plus any losses H_f due to friction or any other causes.

FIG. 3 (ABOVE) TWO VIEWS OF 20-IN. INTAKE METER; (BELOW) 6-IN. INTAKE METER

Thus $$H_{aq} + H_a + H_d = H_a + H_{bq} + H_d + \frac{S^2}{2g} + H_f$$

It is assumed that both the velocity and the friction of flow in the suction bay are so small that they are negligible. This will always be the case if the meter is installed at those distances from the floor and walls which are recommended later in the paper.

Therefore $$H_{aq} - H_{bq} = (S^2/2g) + H_f$$

but $$H_{aq} - H_{bq} = h$$

hence $$h = (S^2/2g) + H_f$$

Now, let $$C = \sqrt{\frac{S^2/2g}{(S^2/2g) + H_f}}$$

then $$S = C\sqrt{2gh}$$

and so $$V = CA\sqrt{2gh}$$

DESCRIPTION OF APPARATUS

Fig. 3 shows a 20-in. meter and Fig. 4 shows general dimensions for the construction of meters of any size. The 6-in. meter was constructed in accordance with these dimensions. Dimensions for the 20-in. meter are shown in Fig. 5. Other sizes have also been built, including both the 15-in. and the 24-in. sizes of welded construction. The 15-in. size is shown in Fig. 6.

The manometer is shown in Fig. 7. This manometer has a glass tube and scale from which readings are taken. The lower end of this tube is connected into a tee connection, one branch of which leads out through a hose nipple into the balance tube which is submerged in the suction bay. The other branch of the tee connects through a by-pass pipe and valve into the bottom of a damping pot. This by-pass valve is normally kept closed.

A small evacuating pump is fastened to the top of the damp-

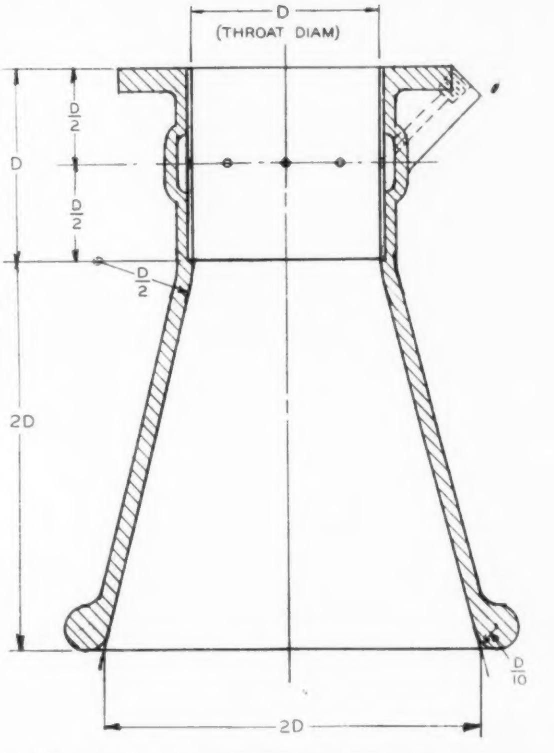

FIG. 4 DIMENSIONS RECOMMENDED FOR INTAKE METER
(Use formula $V = CA\sqrt{2gh}$ and derive C from Fig. 10.)

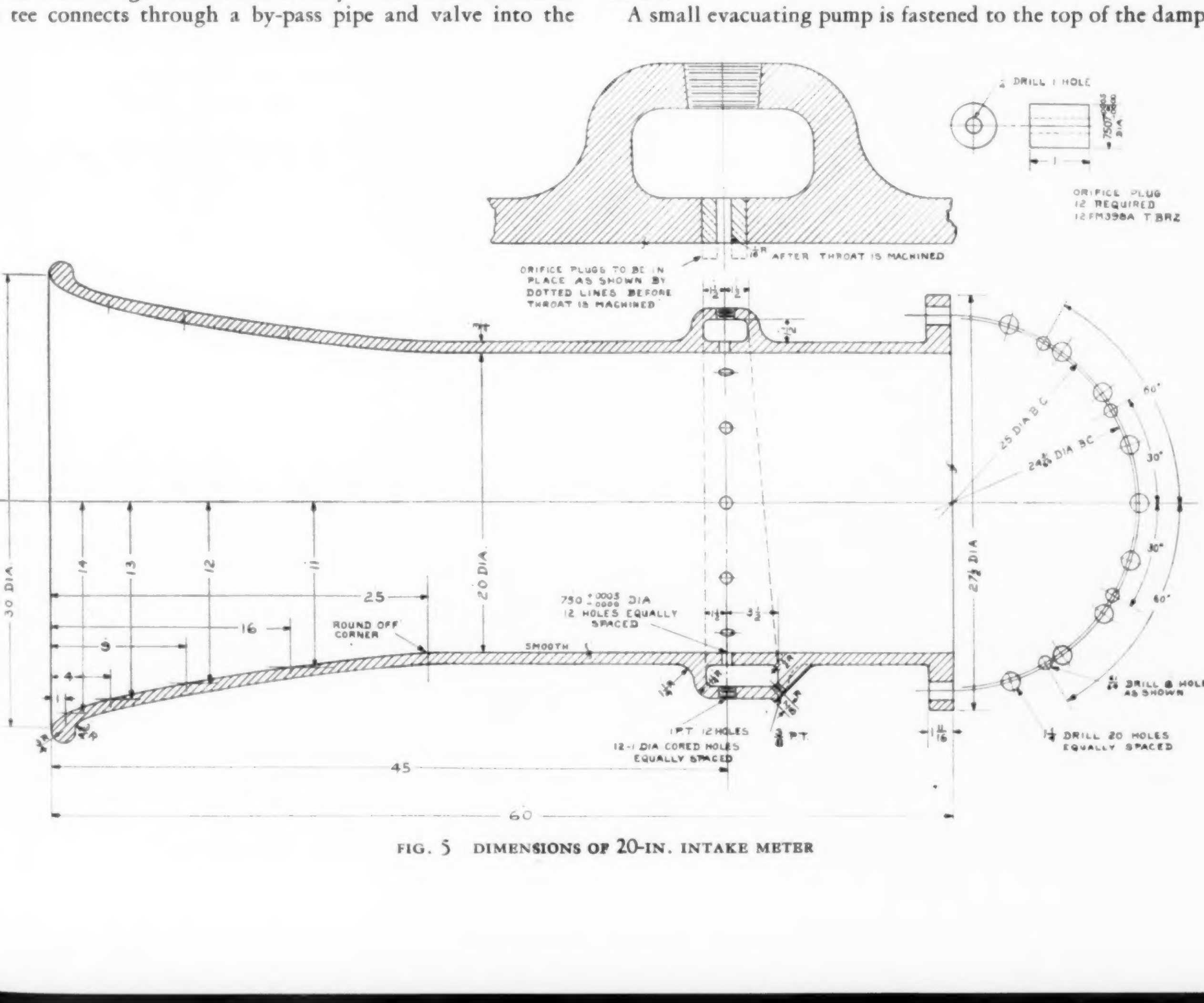

FIG. 5 DIMENSIONS OF 20-IN. INTAKE METER

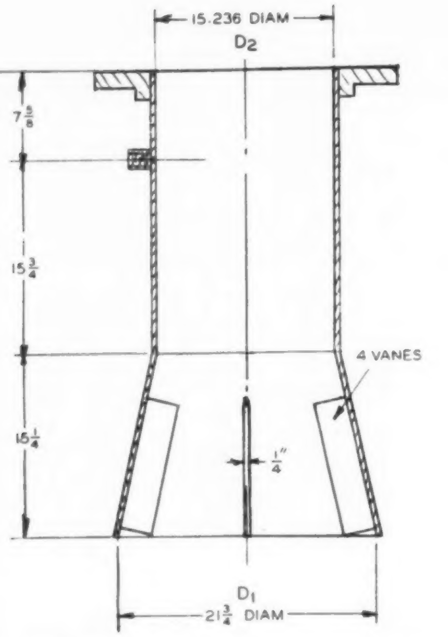

FIG. 6 DIMENSIONS OF 15-IN. WELDED INTAKE METER

(Calibration test showed a coefficient of 0.967 ± 0.5 per cent for an average of four readings at approximately 1,200,000 Reynolds' number. This coefficient is smaller than obtained on 6-in. size because of high ratio of D_2 to D_1 and also because of abrupt entrance at D_1.)

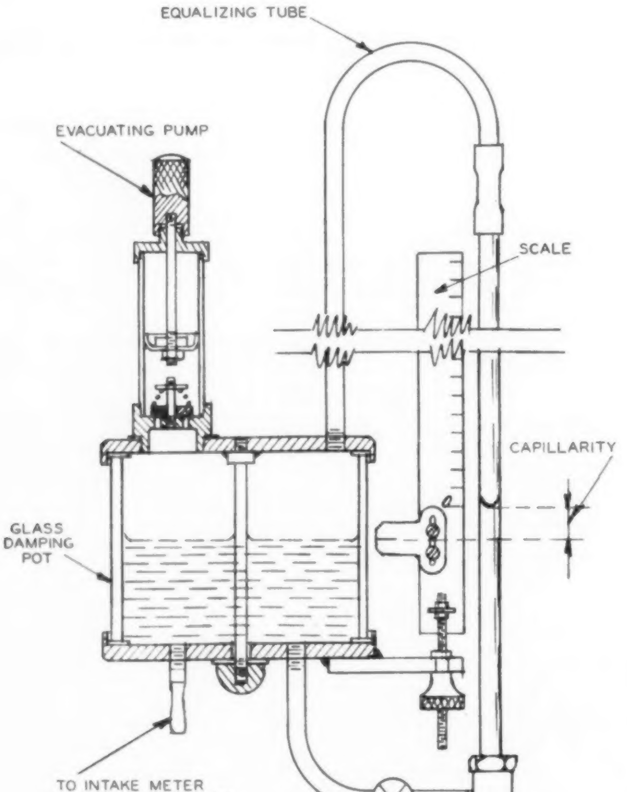

FIG. 7 WATER MANOMETER

ing pot. This pump is used for removing air from the manometer; thus, by means of suction, drawing water up from the suction bay. This evacuating pump is made comparatively small so that it is not possible for the operator to fill the tubes too quickly and entrain air bubbles along with the water. As soon as the water is raised to the desired level, the plunger is screwed down against a gasket which seals the pump against any possible leakage through the valves.

The upper end of the glass water-column tube communicates with the top of the damping pot through an equalizing tube which causes the absolute pressure at the surface of the water in the damping pot to be equal to the absolute pressure at the reading of the water column.

The bottom of the damping pot is connected to the piezometer throat by means of a rubber hose.

Since there is a differential head on the manometer whenever there is a flow of water in the intake meter, there is also a flow of water up from the suction bay, through the by-pass pipe, and down into the intake-meter piezometer, provided of course that the by-pass valve is open. This flow through the connecting hose flushes out any air bubbles which might be trapped at any point. It has been found to be a good practice to open and close this valve before each reading.

On account of the effect of capillarity, the water column in the glass tube at zero flow will evidently stand at a slightly higher elevation than the water level in the damping pot. This is corrected by adjusting the zero for the scale just enough above the damping-pot pointer to compensate for this capillarity.

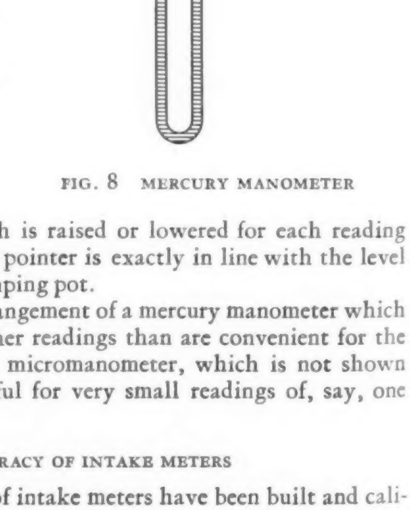

FIG. 8 MERCURY MANOMETER

The scale has a vertical adjustment which is raised or lowered for each reading until the damping-pot pointer is exactly in line with the level of the water in the damping pot.

Fig. 8 shows the arrangement of a mercury manometer which has been used for higher readings than are convenient for the water manometer. A micromanometer, which is not shown in this article, is useful for very small readings of, say, one inch or less of water.

ACCURACY OF INTAKE METERS

Five different sizes of intake meters have been built and calibrated. The earlier tests were less accurate than the more recent ones; experience has been gained as the different meters have been built. A brief description of each meter is given in the paper in order that others may benefit from this experience. Because of the experience gained on other sizes and also because the 6-in. size is the smallest and easiest to handle, it is the one which was calibrated most accurately and which shows the greatest uniformity of coefficients over a wide range of velocities. Fig. 9 shows the results of this calibration in the form of a curve plotted against velocities, and Fig. 10 shows the same results plotted against Reynolds' numbers.

The tests for the 6-in. meter were made by calibrating the readings against flow nozzles of the jet type. These nozzles were screwed to the end of a brass tube having an internal diameter of 7.75 in. and having a piezometer ring for measuring the static head. These nozzles had previously been calibrated against direct measurements of water. Therefore, any inaccuracies of the intake-meter calibration include the inaccuracies of the 3-in. and 5-in. flow nozzles which were used.

The results of this calibration are of a high degree of accuracy, and are at least as accurate as existing tests of venturi meters. There is every reason to believe that with a calibrated instrument of this type, the accuracy depends only upon the degree of fineness to which the manometer can be read. In the present instance the eleven points all fall within less than ±0.5 per cent of the accepted venturi-meter curve.

CAVITATION

No difficulties with cavitation have been encountered in any of the intake meters tested. Nevertheless, cavitation is a theoretical possibility and should be avoided.

The conditions causing cavitation are too well known to require any very extensive discussion here. It is sufficient to say that throat velocities should be kept below the critical value for the pressure and temperature of the liquid being metered. With water at ordinary temperatures any velocity under 30 fps is certainly safe, and this can probably be exceeded without difficulty. Ordinarily, however, throat velocities are considerably below this. The fact that the meter is submerged below the surface of the water gives additional protection, as this positive head adds to the total pressure on the liquid.

The manometer is always located at as low an elevation as convenient, because the suction on the manometer is greater than on the meter due to the difference in elevation. For this reason, cavitation would probably indicate its presence in the form of air bubbles in the manometer before any ill effects would occur within the meter itself.

It is ordinarily recommended that the diameter of the meter throat be the same as the diameter of the suction pipe. When this condition is met, the meter does not increase the total suction lift on the pump. In fact, the total suction lift on the pump, when using an intake meter of the same diameter as the suction pipe, is actually less than the total suction lift without the meter. This is due to the entrance loss which occurs when an open-ended pipe is used, and this loss is eliminated because of the enlarged entrance and easy flow into the intake meter.

Intake meters with throats smaller than the suction pipe have been successfully used, and are perfectly permissible. Throat velocities, however, are higher when this is done, and cavitation might possibly occur especially if the throat diameter is made too small in proportion to the pipe diameter. It is, therefore, considered best to have the diameters approximately equal.

PRACTICAL NOTES

For a design having the highest coefficient, intake meters should be designed in accordance with Fig. 4. This gives the lowest intake loss. The intake loss for any of the meters tested, however, was negligible.

A meter should be selected whose throat diameter is approximately equal to the diameter of the suction pipe.

The manometer should be installed at an elevation not too high above the surface of the water, as this causes the extraction of dissolved air.

The meter should be installed not closer than one throat diameter from the floor. Locating the meter close to the side

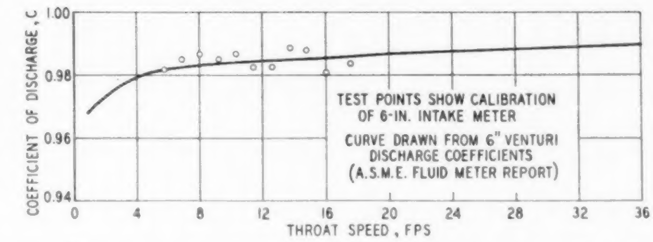

FIG. 9 INTAKE-METER DISCHARGE COEFFICIENTS FOR WATER AT 60 F

(C is defined from $V = CA\sqrt{2gh}$.)

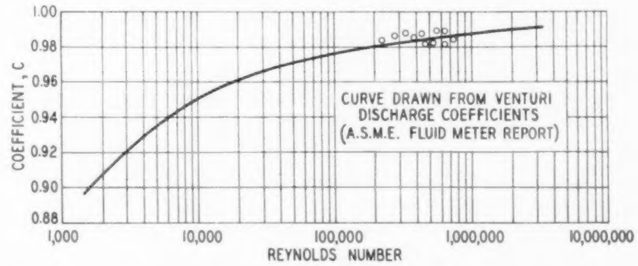

FIG. 10 INTAKE-METER DISCHARGE COEFFICIENTS FOR WATER AT 60 F, PLOTTED AGAINST REYNOLDS' NUMBERS

walls of the suction tank has been found to have no measurable effect upon the accuracy.

The formula for rate of flow is given in Fig. 9. Coefficients for use in this formula are given in the same illustration. The coefficients, as plotted in Fig. 10, are applicable to any size of meter, velocity, and viscosity. The test points have been taken from tests only on the 6-in. meter with water, and the curve has been drawn in from the standard A.S.M.E. Fluid Meters Report. Points above a Reynolds number of 100,000, which will include almost any application for measuring water, are highly accurate. At smaller Reynolds numbers, the curve is only presumptive until calibration tests with air can be carried out.

Rubber-hose connections should be as short as possible, and should slope upward toward the manometer, in order to bring to the surface any air bubbles which might form. Hose having an internal diameter of $^3/_8$ in. or larger is preferable. All connections must be absolutely tight.

On account of the necessity for keeping the connecting hose lines open for the conduction and detection of air bubbles, it is best not to try to steady the manometer readings by throttling. Steady manometer readings can be obtained by submerging the lower end of the balance tube within a pail or other convenient enclosure. If the pail is suspended to such an elevation that the brim is just above the surface of the water, and a small hole is punched in the bottom, extremely steady readings will result.

The accuracy to be expected from any one reading, is ±0.5 per cent, provided all of the foregoing precautions are taken, and provided a manometer is used suitable for readings of this accuracy. Greater accuracy is obtained if several readings are averaged. This procedure is for ordinary commercial use. With a specially calibrated meter, and using a highly sensitive micromanometer, there is probably no limit to the accuracy obtainable.

ACKNOWLEDGMENT

The authors are indebted to Fairbanks, Morse & Company for the use of its test floor and for the illustrations. The assistance of Mr. R. C. Glazebrook and others in preparation of the data is also gratefully acknowledged.

BUILDING *and* BUSINESS[1]

By PAUL A. SAMUELSON

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IN recent years as never before, economists and the informed public have come to regard fluctuations in building and construction as among the most important features of the business cycle. We are indebted, therefore, to Mr. Long for his arduous pioneer efforts in collecting from diverse sources statistical material portraying the American experience with building since the end of the Civil War.[2]

Before entering upon the rich historical and statistical data only now made available, it is perhaps of interest to mention the casual factors underlying the revolution in our attitude toward the causes of the business cycle. Previously, economists and financial experts thought of the business cycle as simply the "dance of the dollar." In periods of prosperity prices rose, and in periods of depression prices fell. And it used to be accepted as an article of faith that the underlying cause of the fluctuation in prices could be directly and unequivocally identified as variations in the quantity of money. This did not necessarily mean that the amount of gold and silver coin or paper notes in circulation varied greatly. Far more important were supposed to be fluctuations in the quantity of *bank money*, that is, demand deposits subject to check. The latter constitutes the most significant part of our money supply, since nine tenths of all transactions are made by checks rather than by cash.

Just as a doctor's prescription varies according to his diagnosis of the patient's illness, so would such an interpretation of the cause of the business cycle lead to certain specific recommendations to effect its cure. If fluctuations in bank money determine the cycle, then regulate the banks, and it will be cured. This led naturally to the creation of the Federal Reserve Banks and to other reforms. When first established before the World War, the Federal Reserve System was considered a radical departure. Today it is regarded as a bulwark of respectability by all parties, by bankers, and by the public. Despite its very considerable achievements, the mitigation of seasonal strains in the money market, to mention only one, the history of the last ten years shows conclusively that it has not abolished the business cycle.

Fanatical adherents of the monetary explanation of the cycle may attempt to explain this by the fact that the Federal Reserve Banks did not have enough legal powers or did not sufficiently exercise those they had. If the prescribed medicine does not cure the patient, give him a stronger dose! Calm dispassionate examination of the factual evidence does not lend credence to this assertion. Unlike the physical scientist the economist cannot perform controlled experiments on his data, and cannot therefore hope to attain the exactitude of the natural sciences. Yet he is occasionally permitted to observe in the statistical data what amounts to the same thing. Because of war scares in Europe, during the last decade vast amounts of gold and capital have poured into the United States from abroad. Better than any imaginable experiment that could be devised, this inflow by lowering interest rates in the United States to fantastic levels should, if the monetary fanatics are correct, have brought about great prosperity.

Unfortunately, the facts were otherwise. And so the honest investigator is forced to cast about for better explanatory hypotheses. As a result economists are increasingly of the opinion that an important casual element of the cycle is to be found in the behavior of real investment. The consumption expenditure of families upon statistical examination is found to bear a rather rigid and uniform relationship to income received. Exceptions to this rule prove to be of minor importance.

If consumer expenditure is passive, we must look toward business and government expenditure as the variable factor in the cycle. When such an examination is made, the following patterns are revealed. Periods of prosperity are characterized by bursts of industrial expenditure, chiefly upon new plant and equipment. Thus, in the latter part of the nineteenth century, railroad building was a strategic factor leading to an upswing in business. In the first part of the twentieth century the growth of public utilities, and still more the automobile industry, led the upswing. The automobile industry was important not so much because of investment by automobile producers, which was relatively small and financed out of plowed-back earnings, but rather because of the investment induced elsewhere as the automobile transformed the face of the countryside. A network of roads, filling stations, suburban developments, subsidiary industries, followed the motorcar's wake.

To the foregoing factors must be added the long-neglected, strategically important building industry. Many will be surprised to learn that in the prosperous twenties one half of the investment upon which the high level of business activity rested took the form of noncommercial residential and public construction. The building boom of the middle twenties, which was itself a result of the accumulated housing shortages produced by the World War curtailment of construction, was an important factor in sustaining prosperity. It was actually far more important quantitatively than the investment of all manufacturing industry. Its decline toward the end of the twenties presaged the final downturn in 1929.

The book under review shows how closely the building cycle and the general business cycle have moved together. By a detailed examination of building permits in all of the large eastern American cities the author has gathered together a monthly index of building in the United States from 1868 to 1920, and has even succeeded in breaking down total building into the constituent parts of detached dwellings, multifamily dwellings, private nonresidential, and public buildings. He shows how all of these, in addition to displaying the ups and downs of short-time business fluctuations, clearly trace out four long cycles of activity averaging about eighteen years in length. The degree of synchronization between the various cities far exceeds what one might have expected in advance. The author carefully sifts currently held reasons for the long cycle and finds that the facts are not consistent with some of them. The belief of many observers that building inevitably turns up before an upswing in general business activity and also leads on the downturn does not appear to be valid. There is a small lag, but this is easily accounted for by the fact that building permits are issued on an average of four months preceding actual construction. In connection with the major long swings of activity it appears that building goes down before general business activity, but turns up after the general upswing. The effect of major wars upon building is immediate and strong.

The first three chapters do not make easy reading because of a tendency to utilize expressions involving the technical jargon of the professional economist. The next nine chapters with an abundance of original factual material are exceedingly rewarding.

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, the Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Building Cycles and the Theory of Investment," by Clarence D. Long, Jr., Princeton University Press, Princeton, N. J., 1940.

SYNTHETICS

Exemplifying Recent Developments Contributed by Scientific Research to Meet Present Needs

By C. P. KIDDER

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BETTER materials of construction are playing an increasingly important role in the economic development of industry, due in part to the more severe requirements of the newer processes and also to the continual changes in established processes to gain greater efficiency, to lower operating costs, and to improve product quality. Added to this normal problem of obtaining and selecting the correct material for a specific application, we are confronted at present with the vital necessity of developing and becoming familiar with substitute or improved synthetic materials so that we may become as self-sufficient as possible if national defense demands.

During times like the present, attention is focused on science. Its past accomplishments are critically reviewed and an even greater effort is asked of it to develop better methods and materials to meet any emergency. Science is fully cognizant of this responsibility. For example, compare the present strategic and critical materials with those that existed during the first world war and note the important developments through scientific research. A few of these materials include nylon, vinyon, fiberglas, magnesium, synthetic camphor, synthetic rubber-like materials, cordura, aviation gasoline, new resins and plastics, and improvements in alloys. Include the advances made in pharmaceutical, medicinal chemistry, and similar advances in other branches of science and we can look with confidence to our country's ability to meet the present crisis.

A complete list of the developments cited or a tabulation of the literally thousands of materials of construction available to the design engineer would be encyclopedic in character and beyond the scope of this paper. Instead, a brief discussion will be presented covering a few of the newer materials that are finding daily application in industry and in our daily home life, and which may find extended usage in the near future.

SYNTHETIC SUBSTANCES WITH RUBBER-LIKE PROPERTIES

Probably one of the most important groups of materials in connection with national welfare is that of the synthetic substances having rubber-like properties. Their adoption would become vital if for any reason our supply of natural rubber should be interrupted. However, aside from this possible future requirement for which we must be prepared, the increased use of resilient materials of construction has created a demand for new materials capable of withstanding service conditions which rapidly deteriorate rubber. Within the last 20 years, the chemical industry has assumed the responsibility of providing these new materials.

As a result of their efforts, there are at present on the market several different synthetic products each of which is, in some respects, similar to rubber. However, none has exactly the same composition as natural rubber and, therefore, in the interest of technical accuracy, none of them can be called synthetic rubber in the accepted sense of the term.

For clarity, these synthetics may be divided into two classes. The first class includes those synthetics which in chemical composition are entirely unrelated to natural rubber, and the second those products similar in chemical composition to natural rubber. In the first group are (*a*) the plastic glyptal resins, (*b*) the alkylene sulphides, such as are sold under the trade name "Thickol," (*c*) polyvinyl alcohol, and (*d*) plasticized polyvinyl resins, such as are sold under the trade name "Koroseal." These products have the rubber-like property of extensibility or deformability under relatively light loads. Certain of them are vulcanizable in a limited sense of the word, that is, they become less plastic and more elastic when heated. However, even after vulcanization these products are still definitely thermoplastic and, under proper conditions, they are even capable of being remolded to other forms. Others are definitely nonvulcanizable and can be hot-molded and remolded without altering their properties materially.

In the second class fall those synthetics such as polymerized butadiene and polymerized chloroprene which in chemical structure closely resemble the primary constituent of natural rubber, isoprene. Typical examples of the former are "Butyl Rubber," "Hycar," "Ameripol," and "Chemigum" which are being produced on a limited scale or are in the process of plant development. An example of the latter, namely polymerized chloroprene, has been available to the trade for some time under the name of neoprene.

These materials, polymerized butadiene and polymerized chloroprene, although they differ slightly chemically from each other and from natural rubber, closely resemble rubber in appearance and in many physical properties. Like rubber they are vulcanizable, that is when mixed with other ingredients and heated under proper conditions they lose their plastic nature and become elastic and resilient, and are less susceptible to changes in properties with changes in temperature. After vulcanization they cannot be remolded to another shape.

Because of the many members in the foregoing classification, this discussion will be limited to neoprene, a synthetic rubber that is being produced in this country on a large scale and which has been proved by innumerable, diversified field applications.

The use of rubber as a construction material has simplified many design problems for the engineer due to its tough, resilient, elastic, and abrasion-resistant qualities. Unfortunately, rubber compositions have a number of limitations which seriously restrict their use in many applications. Rubber products are subject to oxidation. On aging, they deteriorate in physical properties and eventually crack badly. Exposure to sunlight accelerates this deterioration and so does continued deformation, causing cracks to appear at first on the surface and finally all the way through the rubber product. Heat also reduces the life of rubber products causing embrittlement of the surface and eventually causing the whole rubber mass to

Contributed by the Process Industries Division and presented before a meeting of the Philadelphia Section, Philadelphia, Pa., January 28, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

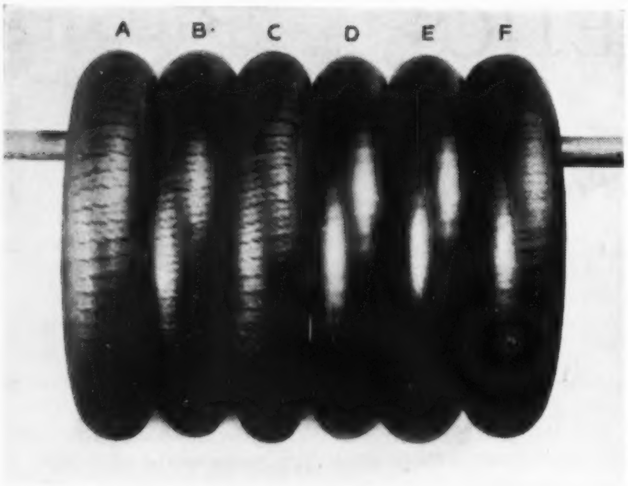

FIG. 1 HOSE SURFACES EXPOSED TO DIRECT SUNLIGHT FOR 4 WEEKS
(The Neoprene covers are samples *D* and *E*.)

become soft and sticky. Many chemicals attack rubber and seriously impair its serviceability. Exposure to petroleum products causes rubber to swell excessively, and this swelling is accompanied by such rapid deterioration of physical properties as to make rubber useless for even ordinary service in a comparatively short time.

It is true that tremendous advances in rubber technology have widened the field for products made from rubber by imparting to these products a greater ability to retain their original useful properties, even under difficult service conditions. However, even the best rubber compositions still have many shortcomings.

SPECIAL QUALITIES OF NEOPRENE

It is particularly under conditions of exposure which deteriorate rubber that neoprene compositions find their greatest usefulness. In brief, neoprene exhibits the strength, toughness, elasticity and abrasion resistance of rubber, but has a plus value in its inherent resistance to oxidation, sunlight, heat, chemicals and oils. Further, neoprene compositions are flame-resistant.

Neoprene compounds are many times more resistant to oxidation than even the best modern rubber compounds. Direct sunlight has practically no effect on the materials, the only change being a stiffening on prolonged exposure, whereas, rubber products such as garden hose and automobile-tire side walls exhibit the effect of "sun-checking."

This condition is well illustrated in Fig. 1 which shows the results of a 4-week test in which commercial samples of rubber- and neoprene-covered hose were continuously flexed mechanically while exposed to the intense rays of the sun in Florida. Samples *D* and *E* are the neoprene covers which remained in good condition after an additional 6 months of exposure.

Neoprene compounds show a marked superiority to similar compounds of rubber with respect to heat resistance. Special compounds show the greatest superiority at temperatures between 180 F and 300 F. The fundamental difference in the effect of elevated temperatures on rubber and neoprene is that vulcanized-neoprene compounds never undergo reversion (softening and weakening) such as occurs to the best heat-resisting rubber. Neoprene gradually hardens when exposed to elevated temperatures.

In Fig. 2 are shown a rubber and a neoprene section taken from a test conveyer belt which carried nickel fines at 600 to 700 F. The section illustrated was removed after 8 months of service and, as may be seen, the rubber belt (top) softened exposing the fabric, while the neoprene sample (bottom) was still usable after 11 months, even though the extreme heat had hardened the surface.

Another interesting property of neoprene compounds is their resistance to abrasion even though oil-soaked. In Fig. 3, top, are shown similar rubber and neoprene compounds which were abraded with a rotating wire brush for an equal time. At the bottom of Fig. 3 are shown the same stocks after immersion for two days in S.A.E. 30 oil at 100 C, and then exposed to the same wire-brush abrasion tests.

Neoprene resists to a remarkable extent deterioration by many of the chemicals used in industry. In some cases, a special compound should be used for a specific type of chemical and, for this reason, a small-scale test is often advisable before making an extensive installation. Neoprene will swell slightly from contact with oils, but to a much less extent than rubber and, what is of greater importance, it retains its strength, toughness, elasticity, and abrasion resistance to a remarkable degree even when swollen. The heavier fractions of refined crude oil have less effect on neoprene than the lighter ones. For example, lubricating oil deteriorates this material at a slower rate than does kerosene or gasoline.

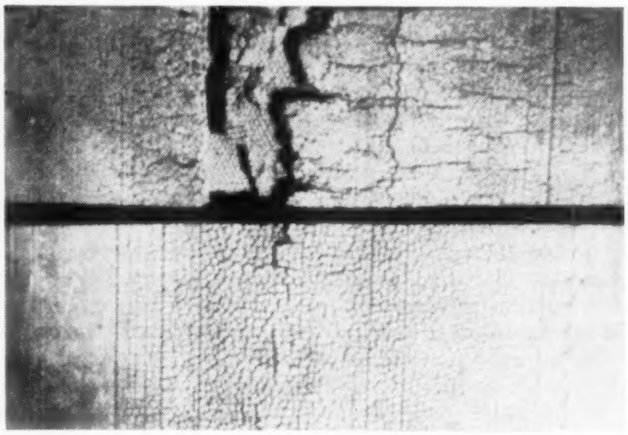

FIG. 2 CONVEYER BELTING USED AT ELEVATED TEMPERATURES, SHOWING COMPARATIVE HEAT RESISTANCE OF RUBBER, TOP, AND NEOPRENE, BOTTOM

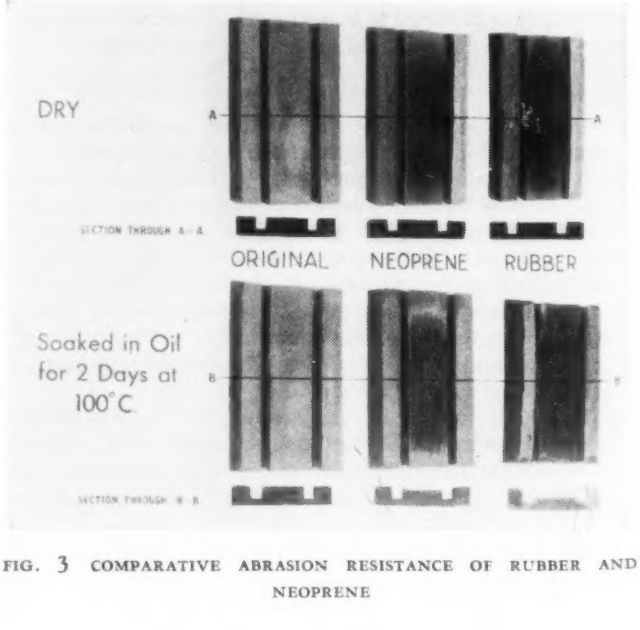

FIG. 3 COMPARATIVE ABRASION RESISTANCE OF RUBBER AND NEOPRENE

Fig. 4 shows in graphic form the effect of S.A.E. 30 lubricating oil at 82 F, for periods up to 219 days on the volume and tensile strength of typical neoprene and rubber compositions. The results of a similar test after 21 days' immersion in crude oil are illustrated in the bar charts of Fig. 5.

TYPICAL APPLICATIONS OF NEOPRENE

A practical application to illustrate the oil-resisting properties of neoprene is given in Fig. 6, which shows the condition of a cable after service in a shop where it was subjected to oil. At the top is a section from the original cable; at left is neoprene-jacketed cable after a year's service; and at the right a high-grade rubber cable after 6 months' usage.

Some of the more interesting applications where neoprene is proving suitable and economical include (1) neoprene-covered wire and cable, (2) transmission and conveying belts for installations where heat and oil are encountered; (3) hose for transportation and distribution of oil and gasoline, oil emulsions, fuel gases, and compressed air that may contain hot oil; (4) gaskets and sealing rings in hot and corrosive service; (5) compressor seals for refrigerants and door seals for refrigerators; (6) diaphragms for use in automatic switches, fuel pumps, gas regulators, flow valves, and many similar applications; (7) other applications consisting of tubing, stoppers, shoe soles and heels, printing rollers, protective clothing, boots, industrial gloves, household gloves, and aprons.

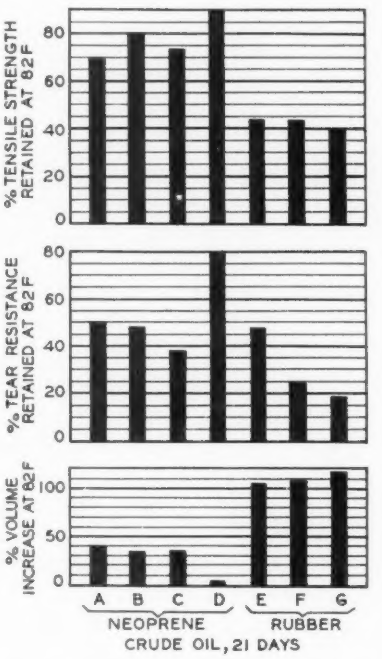

FIG. 5 EFFECT OF IMMERSION FOR 21 DAYS IN CRUDE OIL AT 82 F ON TENSILE STRENGTH, TEAR RESISTANCE, AND VOLUME OF SIMILAR RUBBER AND NEOPRENE COMPOUNDS

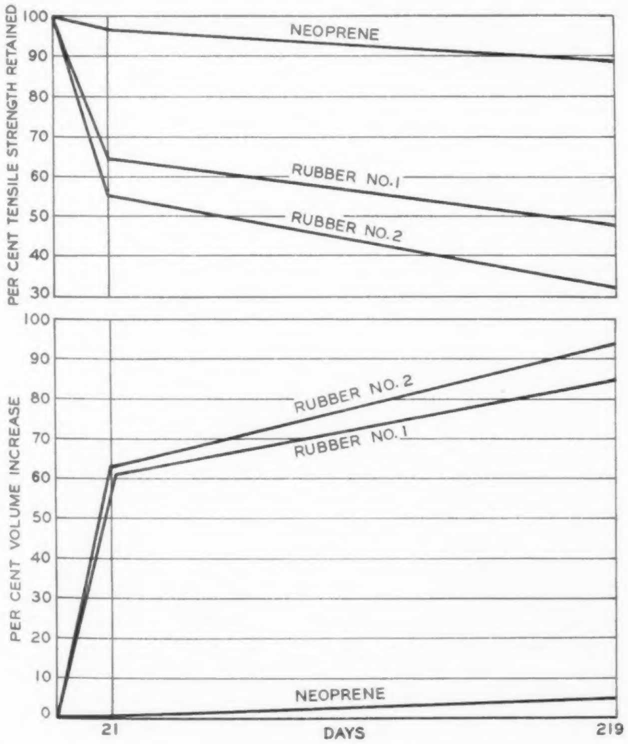

FIG. 4 EFFECT OF IMMERSION IN S.A.E. 30 LUBRICATING OIL AT 82 F ON TENSILE STRENGTH AND VOLUME OF SIMILAR RUBBER AND NEOPRENE COMPOUNDS

Neoprene, like rubber, has its limitations. Coal-tar solvents, aromatic hydrocarbons, chlorinated solvents, and acetic acid all cause pronounced swelling and deterioration in physical properties. It is not recommended for use with strong oxidizing chemicals such as concentrated chromic and nitric acids, though it will withstand dilute and medium concentrations of sulphuric acid at moderate temperatures. Although more heat-resistant than rubber, neoprene is still far short of the ideal in this respect. The general conclusion should not be reached that neoprene will perform satisfactorily wherever rubber has failed. On the other hand this new product has solved many troublesome engineering problems.

Neoprene has a specific gravity of 1.25 with a possible range of 1.4 to 3 for pigmented mixes. Its tensile strength may range from 200 to 4000 psi for various compounds and, in general, is comparable to like compositions of rubber. Abrasion resistance under normal conditions is similar to that of rubber, and any advantage under severe conditions would be due to its superior resistance to deteriorating influences. Diffusion of many gases takes place at a slower rate through neoprene than through rubber. Neoprene compounds are inferior to similar rubber compounds in power factor and volume resistivity. However, they show remarkable resistance to corona and are widely used as protective coverings for rubber insulation. Under dynamic loads, neoprene compounds exhibit a more rapid damping effect than like rubber compositions and, therefore, may be used to advantage for vibration absorption. Although neoprene compounds must be classed as heat insulators, a comparison of "pure-gum" stocks shows a 28 per cent greater thermal conductivity for neoprene.

NYLON, A RECENT DEVELOPMENT OF SYNTHETIC CHEMISTRY

Let us now consider another material which is a very recent development of synthetic chemistry and an outstanding illus-

FIG. 6 ORIGINAL CABLE, TOP; RUBBER-COVERED CABLE, RIGHT, AFTER 6 MONTHS; AND NEOPRENE-COVERED CABLE, LEFT, AFTER 1 YEAR OF EXPOSURE AT SAME OILY LOCATION

tration of chemical research, namely, nylon. This synthetic is of extreme interest at the present time, since it is a distinctly new material chemically, but affords physical properties that are equal or superior to silk, one of the strategic materials. In 1940, approximately 51,000,000 lb of silk were imported by this country and, while about 75 per cent went into hosiery, considerable quantities were used for the manufacture of certain essential military products, including parachute fabrics and shroud lines, powder bags, and flare cloths. In order to manufacture these materials, a yarn is required that possesses high elasticity and tensile strength with light weight. Until the development of nylon, silk was the predominant material that met these requirements. It is the author's understanding that there is no substitute for silk in powder bags, but that cotton and cordura parachute fabrics have been made.

Nylon is the generic name coined by the author's company for all synthetic fiber-forming polymeric amides, having a protein-like chemical structure, derivable from coal, air, and water, or other substances. Nylon may be formed into fibers, bristles, sheets, and other shapes and is not limited to fibers or yarn.

One of the most interesting physical properties of nylon is that it becomes truly elastic when cold drawn to from 4 to 7 times its original length, depending upon the particular type of polyamide being used. When the drawn form is stretched further it will return to the original length upon release of tension. Fig. 7 gives comparisons, in elastic recovery, between the fibers, silk, two types of regenerated cellulose rayon, acetate rayon, and nylon. In this test, the samples were stretched 4 per cent, held for 100 sec, and measured 60 sec after the load was released. Nylon showed 100 per cent recovery in comparison to 50 for natural silk, 50 for acetate rayon, 40 for cordura rayon, and 30 for ordinary viscose rayon. Nylon can be drawn into fibers which, for a given size, are stronger than corresponding fibers of cotton, linen, wool, silk, or rayon.

Aside from hosiery, the extreme toughness of nylon filaments makes it suitable for brush bristles and affords long-wearing fish lines that are highly resistant to fraying.

Nylon, being a crystalline material, has a definite melting point for each composition. Some forms melt at a low temperature while others may run up to 600 F. The type in general use for textile purposes has a melting point of approximately 480 F. This, fortunately, is above the temperature normally used in ironing fine fabrics. Nylon yarn and fabrics are practically nonflammable. They are not injured by water or any of the liquids commonly used around the home. Nylon is physiologically inert and has found use in the form of surgical sutures. In addition, it is resistant to enzymes, mildew, molds, and moths. While it is attacked by certain chemicals such as the mineral acids, and phenols and formic acid are active solvents, on the other hand, it does show resistance to certain concentrations of acetic acid, toluene, sodium oleate, formalin, liquid freon, all of the common dry-cleaning solvents, and certain bleaching agents. It is also resistant to alkalies even in fairly concentrated solutions at elevated temperatures, Fig. 8.

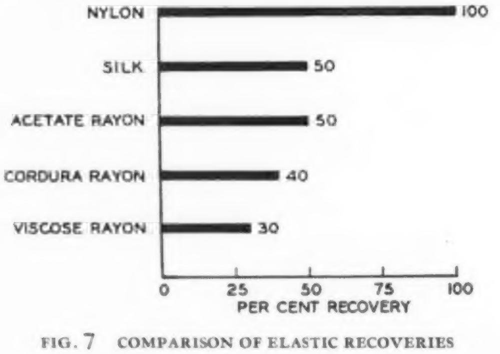

FIG. 7 COMPARISON OF ELASTIC RECOVERIES WITH AN IMPOSED LOAD

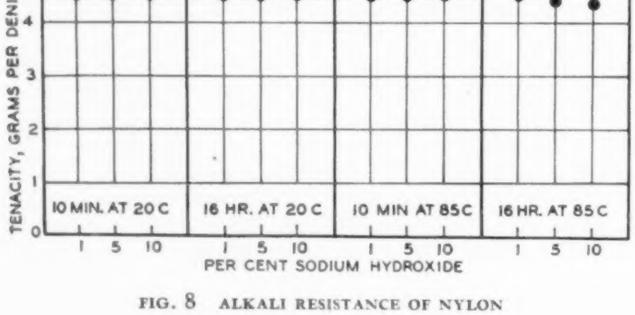

FIG. 8 ALKALI RESISTANCE OF NYLON

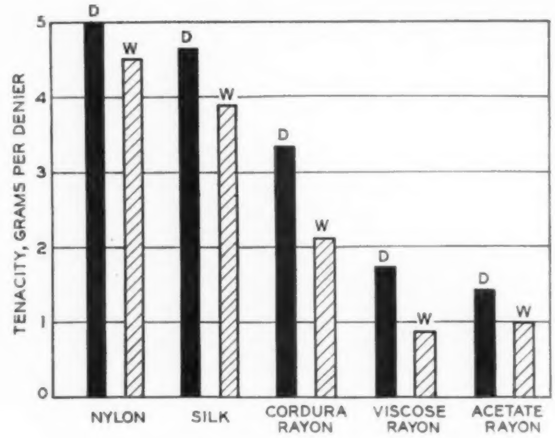

FIG. 9 TENACITY OF SEVERAL FIBERS

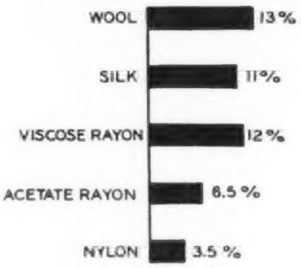

FIG. 10 WATER ABSORPTION AT 60 PER CENT RELATIVE HUMIDITY

The tensile strength, dry, of the fiber is approximately 72,500 psi, with an elongation, which may be varied over wide limits, of 20 per cent and an elastic recovery, against no load, of 100 per cent for stresses up to 8 per cent and 91 per cent elastic recovery for 16 per cent stretch.

Fig. 9 compares average strengths, wet and dry, for nylon, silk, Cordura rayon, viscose rayon, and acetate rayon. It should be understood that appreciable variations may occur, depending upon the samples chosen.

Fig. 10 shows water absorption at a relative humidity of 60 per cent, for several types of fiber.

The major portion of the present plant production is going into yarn for fine hosiery. However, the use of nylon in the manufacture of bristles for both toilet and industrial brushes is finding increasing applications in place of animal bristles which are mostly imported from the Orient.

The extended application of nylon into fields other than those previously mentioned has been retarded due to the demand for production in the present fields of usefulness. It is also

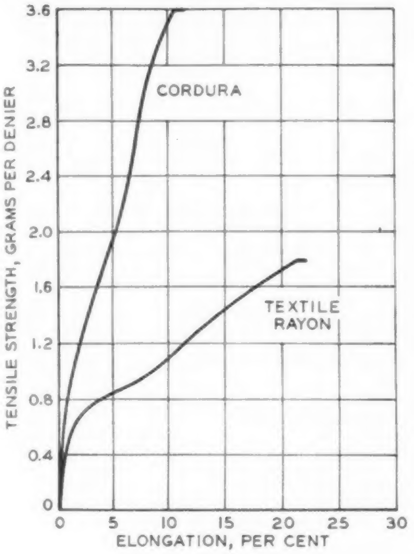

FIG. 11 COMPARATIVE STRENGTH OF CORDURA AND TEXTILE-RAYON YARNS, MEASURED ON INCLINED-PLANE TESTER UNDER LOAD OF 4 G PER DENIER PER MIN

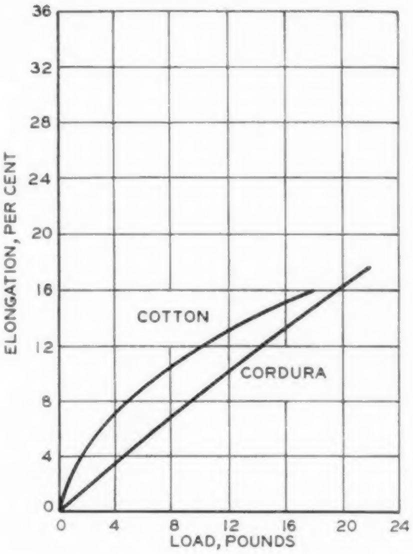

FIG. 12 STRESS-STRAIN RELATIONSHIPS OF CORDURA AND COTTON TIRE CORDS SHOW NO RAPID INCREASE IN ELONGATION WITH RISING LOAD FOR CORDURA

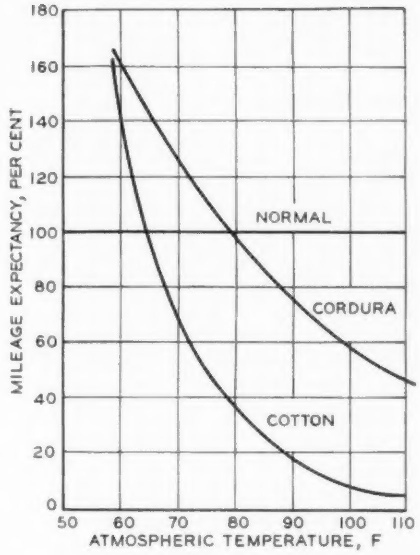

FIG. 13 PERFORMANCES OF CORDURA AND COTTON TIRES UNDER VARYING TEMPERATURES WHERE BOTH HIGH SUSTAINED SPEED AND OVERLOAD ARE INVOLVED

deemed necessary to collect and correlate test data in new applications before extended usage of this radically new material is advocated. However, potential applications may include the use of nylon for bushings, filter cloths for specific chemicals and oils, rope due to the high attainable ratio of strength to weight, fabric and shroud lines for parachute construction, powder bags, and flare cloths. Because of its good insulating properties and abrasion resistance it may find use as wire insulation in various types of electrical and refrigeration services. Possible textile applications for the yarn would include knit goods, woven goods, lace, upholstery material, and the like. Strings for tennis rackets have been announced and a rather unique use is cross hairs for telescopes, since nylon may be produced as fine as a spider's web and stronger than silk.

CORDURA RAYON FOR TIRES

As car drivers, we are interested in the safety and economy of pleasure and commercial motorcar operation. One of the recent contributions of research to the improvement of tire mileage and safety is Cordura rayon for tire construction.

Tire mileages during the early days of the horseless carriage approximated 2500 miles and that was considered excellent at the terrific speed of 25 mph. It is apparent that rapid advances have been made in tire construction to enable the improved service life now attained at our present speeds of 40 to 60 mph. Most of this advance in tire performance has been possible through the development of the cord tire. However, in order to keep abreast with the progress of the automotive engineer and the ever-increasing stresses caused by heavier loads and higher speeds, the tire manufacturers are introducing a further advance in tire construction by offering tires constructed of Cordura-rayon cord in place of cotton. Cordura is the trademark name given to a new viscose-rayon yarn that was developed especially to afford a tough, high-tensile cord for tire-fabric purposes.

Initial attempts were made about 16 years ago to fabricate tire cords from rayon but these were unsuccessful, due to the low tensile strength and high permanent elongation obtained at low loads with the rayon produced at that time. However, continual research and investigation has resulted in the development of Cordura rayon, which is outstandingly superior to standard rayon in tensile strength, with a value of approximately 70,000 psi, which is twice as strong. Comparative values for Cordura and textile rayon are shown in Fig. 11.

Another important property of Cordura is that tire cord made from it shows no rapid increase in elongation with increasing load, Fig. 12. This factor is extremely important in tire design. Also, the fact that Cordura cords when heated to 250 F lose only 12 per cent of their normal strength, while cotton cords lose 30 to 50 per cent is another major advantage of the former material for tire construction.

The relative performance characteristics of cotton and Cordura rayon, based on a large number of carefully controlled tests covering many millions of miles, are shown in Fig. 13. From this graph, it may be seen that the mileage expectancies for rayon and cotton are about the same at 60 F; but, as the temperature rises, the Cordura-rayon tire forges ahead, giving twice the mileage at 75 F and 10 times the mileage at 105 F.

SALT TREATMENT OF WOOD—A PRESERVATIVE AND FIRE-RETARDANT

It is of interest to note that the materials so far considered have been products which find application industrially and at home. Another chemical development which likewise has a dual interest to many of us is chromated zinc chloride, a recent advance in the field of wood preservation and fire retardation.

In selecting correct materials of construction, considerable thought is usually given to the proper choice of metal, alloy, plastic, or ceramic. However, there is a tendency in the case of wood, one of our commonest and oldest construction materials, to pay inadequate attention to suitable preservative treatments.

While there are several wood treatments on the market that have a definite field of usefulness, we are limiting our discussion to the chromated-zinc-chloride salt treatment of lumber. Zinc chloride, the active ingredient in this chemical salt has been in use as a wood preservative for over 100 years, but it is only recently that this chemical has been offered to the wood industry in an improved form, namely chromated zinc chloride.

The termite-repellent value of treated lumber is convincingly illustrated by a test house that was built from preserved lumber in one of the world's most heavily infested termite regions, the

island of Barro Colorada, Panama Canal Zone. After 13 years, the house remains free from termite attack and in a perfect state of preservation. Untreated wood placed inside the house was destroyed in approximately 1 year. A further illustration of the economic advantage of this wood-preservative treatment may be gained by observing actual service records for railroad ties which show that treated ties last 3 to 10 times longer than untreated ones, depending primarily upon service conditions and the species of wood involved. In the home, treated lumber may be expected to outlive the normal life of the structure. In addition to these advantages of decay resistance, termite repellence, and its noncorrosive effect on hardware, chromated-zinc-chloride treatment of lumber offers other advantages. It is odorless, does not impart an objectionable color to lumber, does not present any health hazard in use or in handling and, finally, acts as a fire-retardant. This latter property of fire retardation is being recognized as an extremely desirable feature as illustrated by the fact that the Federal Government is specifying chromated-zinc-chloride treatment of lumber for the construction of explosives plants and defense bases both within and outside of the country.

Other practical applications include its use for roofs, studding, and joints, in industrial buildings, subjected to high humidities, in buildings where smoke and fumes corrode metal parts, on the highway for guardrail posts and bridge decking, for mine timbers and railroad ties, and for the structural parts used in house construction.

"LUCITE," A TRANSPARENT PLASTIC

"Lucite" is another member of the plastics field which deserve consideration. A little over 3 years ago, the first pieces of Lucite, the trade name of methyl-methacrylate resin and thermoplastic molding powder, were commercially available. Crystal-clear, strong, light, easily worked, this unusual plastic prompted many prophecies as to future usage. Many of these prophecies have come true and many new uses have sprung up.

Many states have installed molded Lucite reflectors to define the highway and warn the motorist of dangers ahead. A six months' record of an installation on a 70-mile stretch of road in Michigan indicated that the reflectors had helped to reduce night accidents 79 per cent, as compared to the previous year. Lucite molding powder is also being used extensively for the fabrication of radiator ornaments, steering-wheel-insignia coverings, tail-light directional signal, and instrument, radio, and clock panels on many of the pleasure cars. A builder of bodies for buses is splitting colored and transparent Lucite tubes for sturdy light-diffusing panels along the interiors of buses.

FIG. 14 PIPING COOL LIGHT TO A PATIENT'S MOUTH

Lucite in the form of cast sheets is proving useful to the aircraft industry for the construction of windshields and windows for airplanes, due to its low density, lack of brittleness, clarity, and stability to light exposure. Double sheets of thin Lucite make the windows mistproof, a valuable feature for many flying conditions. Molded parts are being used extensively in the construction of military planes for the fabrication of various-formed shapes, such as enclosures for gun turrets, where visibility and light weight are of prime importance.

In the fields of medicine and dentistry Lucite is playing an outstanding part through its ability to transmit light around corners. Instruments made of this plastic in various shapes carry "cold" light from one end of the instrument to the other and permit strong illumination, without heat, of the nose, ear, throat, or other affected parts, Fig. 14.

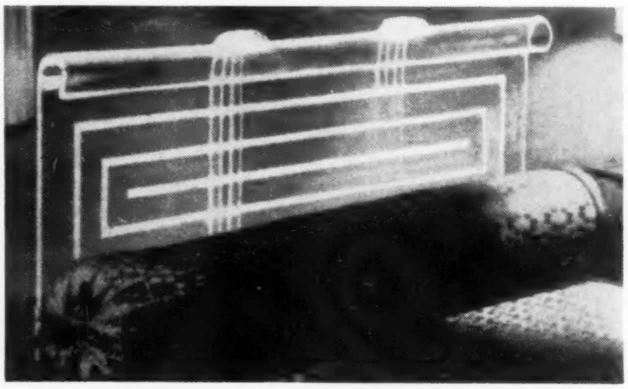

FIG. 15 DECORATIVE PLASTIC HEADBOARD INCORPORATING "PIPED" LIGHT FROM FLOOR

In the field of household furnishings, Lucite is used for doorways, framing pictures, and decorative effects; also, for the construction of chairs, ash-receiver stands, fireplace baskets, doorknobs, and legs for piano benches.

In Fig. 15, we see where the decorative and illuminating characteristics of this plastic have been combined to design a novel lie-abed reader in the form of a headboard. The lighting is piped from the floor.

Many industrial firms have taken advantage of the clear quality and easy-working properties of Lucite in constructing models of their equipment. The transparent reproduction of the part permits showing the interior "workings" in an attractive manner. It is also being used for transparent, durable windows for industrial equipment. Fig. 16 illustrates a transparent dialyser which enables visual inspection of a process-operation

In the display field, Lucite is rapidly becoming recognized as an excellent material for store-window and counter displays, due to its ability to be shaped into attractive designs heretofore impossible to build economically.

The unusual chemical properties of this plastic are also of interest. Since its water absorption is extremely low, it is unaffected by water solutions of mineral salts or dilute alkalies. It is resistant to hydrochloric acid and 50 per cent sulphuric acid at room temperature. It is insoluble in straight-chain hydrocarbons, and in most fats, oils, and waxes. Moldings made from hard Lucite will not resist alcohol in excess of 25 per cent and are attacked by ethyl ether. Moldings made from powders containing plasticizers and lubricants are not as resistant to chemical reagents as the pure methyl methacrylate or cast material. It is readily dissolved by the lower ketone and ester solvents, and mixtures of aromatic hydrocarbons with small amounts of alcohols. The material is difficult to ignite but when ignited by direct flame it will support combustion.

In addition to its many desirable chemical properties and

TABLE 1 PROPERTIES OF UNPLASTICIZED POLYMERIC METHYL METHACRYLATE

General:	
Density, 25 C	1.19 to 1.20
Hardness, Brinell scale	25–28
Softening temp, C	80–125
Shrinkage of molded resin, in./in.	0.003–0.005
Water absorption, per cent	about 0.5 or less
Mechanical:	
Tensile strength, lb per sq in.	8,000–11,000
Impact strength (A.S.T.M. notched) ft per lb	0.23–0.27
Modulus of elasticity, lb per sq in.	$2.3–3.0 \times 10^5$
Fiber stress, lb per sq in.	13,000–18,000
Thermal:	
Thermal conductivity, Btu per sq ft per hr per deg F per in.	1.25
Coefficient of linear expansion	$8.2–9.5 \times 10^{-5}$
Optical:	
Refractive index	1.482–1.521
Light transmission	95%
Ultraviolet transmission (0.01-in. film) *A*	To 2500
Light stability	Excellent
Internal reflectability	Good
Electrical:	
Volume resistivity, ohms per cc	$2.0–3.0 \times 10^{13}$
Dielectric constant (60 cycles):	
25 C	3.3–4.5
100 C	5.0–6.0
Power factor (60 cycles), per cent:	
25 C	6.5–8.0
100 C	1.0–4.0
Dielectric strength (in oil at 100 C):	

Insulation thickness, in.	Dielectric strength, volts per mil
0.054	741
0.063	687
0.092	615
0.245	347

Arc resistance	Does not track
Inflammability	Slow burning
Solubility:	

Soluble in esters, ketones, aromatic hydrocarbons, chlorinated hydrocarbons, anhydrous organic acids

Insoluble in water, aliphatic alcohols, lower aliphatic ethers, aliphatic hydrocarbons, vegetable oils, glycols, carbon tetrachloride, formamide, phosphoric acid (70 per cent), hydrochloric acid (30 per cent), sulphuric acid (60 per cent), aqua ammonia, sodium hydroxide (30 per cent)

outstanding clarity, this plastic has many desirable physical properties such as high softening temperature, high tensile strength, good dielectric properties, low specific gravity, excellent light stability, and good ultraviolet transmission. A summary of these general properties is given in Table 1.

As for working properties, the material may be sawed, cut, turned on a hand lathe, drilled, and, being a thermoplastic, may be formed or swaged by heating in water to 200 to 240 F prior to forming.

This unique transparent plastic is available to the fabricator as a cast resin in the form of sheets, rods, and tubes, and as a thermoplastic molding powder. In both forms it is available as a lightweight, flexible product either crystal clear or in a variety of brilliant transparent, translucent, and opaque colors.

In summary, we have selected from the broad field of new synthetic materials a few outstanding products that have been placed on the market quite recently to supplement, improve, or replace, if necessary, certain vital material requirements. These products, namely, neoprene, nylon, Cordura rayon, chromated zinc chloride, and Lucite, exemplify recent developments contributed by scientific research to meet our present needs and requirements.

Neoprene is the synthetic material with rubber-like properties which reduces our dependency upon natural rubber, if our supply should be cut off. At the same time, it affords a resilient material superior to natural rubber for many chemical and physical applications.

Nylon, the true synthetic plastic, may be formed into fibers, bristles, sheets, and other shapes and can, in certain of its forms, be a completely satisfactory replacement for silk.

Cordura rayon, the new viscose-rayon fiber which was developed especially to afford a tough, high-tensile yarn, is superior to cotton cord for tire-fabric construction.

Chromated zinc chloride has been developed for the treatment of lumber to obtain an odorless, fire-retarding wood preservative.

Lucite, the crystal clear, lightweight, strong plastic resin and thermoplastic molding powder is finding wide application for roadway markers, automotive and airplane construction, illumination instruments in the fields of medicine and dentistry, and also in this latter field for making dentures, for household furnishings, in the display field, and industrially where a durable, lightweight, transparent, readily fabricated material is required.

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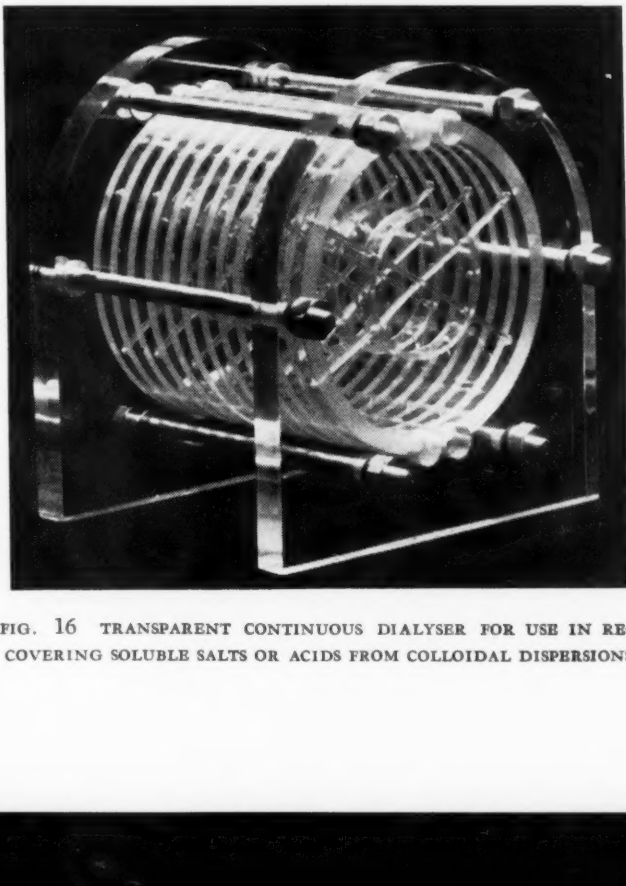

FIG. 16 TRANSPARENT CONTINUOUS DIALYSER FOR USE IN RECOVERING SOLUBLE SALTS OR ACIDS FROM COLLOIDAL DISPERSIONS

A New Circulation-Type WATER BRAKE

By H. F. SCHMIDT

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, EAST PITTSBURGH, PA.

TURBINE-DESIGN engineers throughout the country, and members of this Society in particular, will recall a program of cooperative research which was initiated during the year 1940, by the Philadelphia Electric Company and the Westinghouse Electric & Manufacturing Company at the former's Schuylkill Station. The object of this program was the investigation of the vibratory characteristics of partial-admission impulse elements in superposition turbines, operating with high initial steam conditions. For that purpose a Westinghouse 10,000-kw developmental turbine-generator unit was installed in the Schuylkill Station, provided with means for obtaining optical records of blade vibration under various and variable operating conditions. The scope of this program, as well as details of the turbine and the optical equipment, have been discussed in papers presented before the Society.

A vital requirement for this experimental unit was, of course, provision of suitable means for varying the turbine load and speed at will and in any desired increments. This requirement posed the alternatives of elaborate and cumbersome electrical energy-absorption equipment, or a mechanical or hydraulic dynamometer of an unprecedented range of capacity, capable of absorbing at least 10,000 hp at 3600 rpm.

Energy-absorption devices of various kinds have been used for many years in the testing of prime-mover equipment. The earliest was probably the "prony" or mechanical friction brake, which is still used to some extent for testing small internal-combustion engines and similar purposes. Later, the hydraulic dynamometer or water brake came into being and, for electrical apparatus, air or water rheostats were devised. None of the existing types, however, had the necessary capacity, combined with sufficient flexibility and compactness, to be satisfactory for this application.

It was, therefore, decided to build a high-speed water brake as the most flexible and compact means which could be provided to serve the desired ends. As a result, a circulation-type brake, shown in Fig. 1, was constructed and installed between the development turbine and its generator, so that either brake load or station electrical load can be used. Members of the Society who have visited the Schuylkill plant have shown considerable interest in the brake. Therefore, it was thought that a brief description of the equipment would be of some interest.

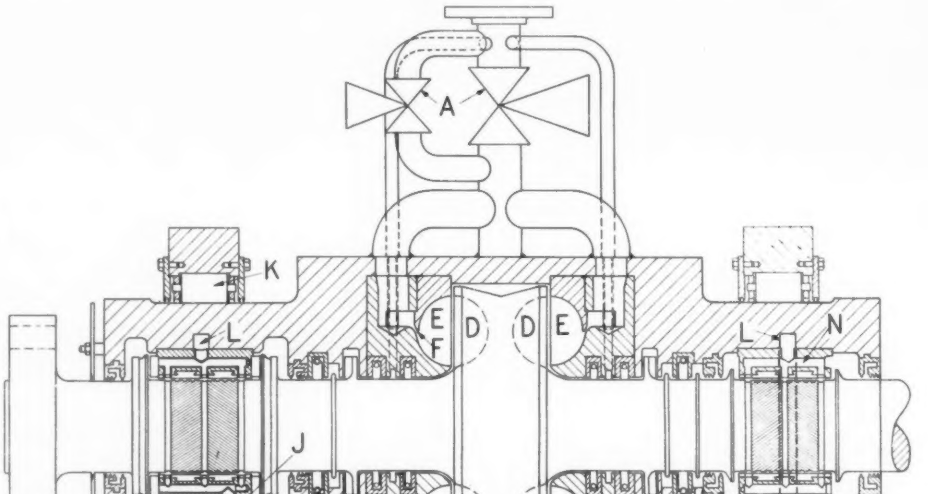

FIG. 1 CROSS SECTION OF CIRCULATION-TYPE WATER BRAKE, DESIGNED FOR 30,000 HP AT 3600 RPM

PROBLEM INVOLVED IN DESIGNING THE BRAKE

The general characteristics of a hydraulic dynamometer are the same as those of all hydraulic machinery, namely, that the power varies substantially as the cube of the revolutions per minute. Consequently, it will be seen that, if the brake were designed for 10,000 hp at 3600 rpm, at 1800 rpm it would be able to absorb but $^1/_8$ of the power absorbed at 3600 rpm. However, since it is necessary for the purpose of the blade tests to keep the steam flow substantially constant during variable-speed runs, it

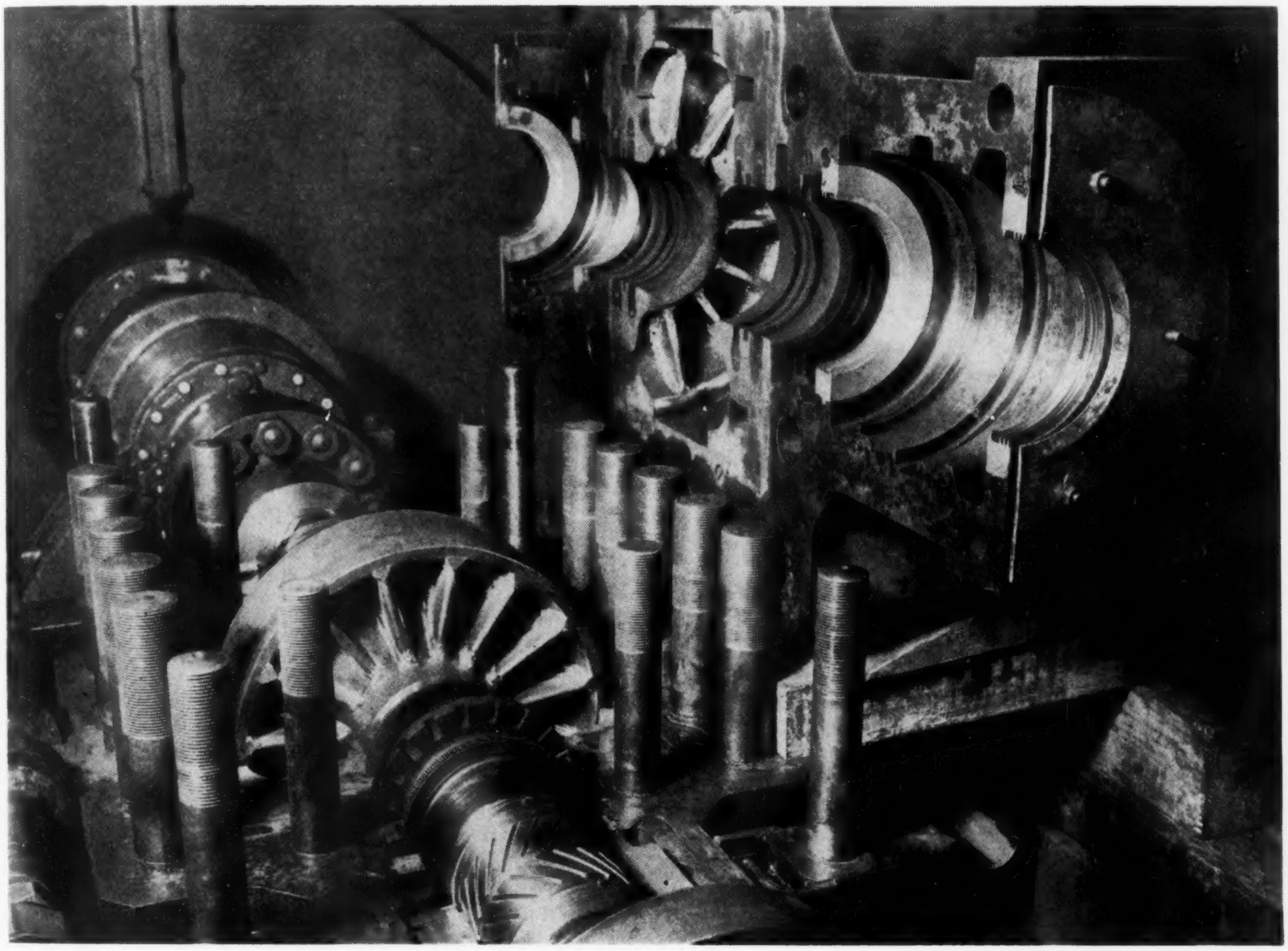

FIG. 2 BRAKE AS INSTALLED ON BLADE-TESTING UNIT AT SCHUYLKILL STATION OF PHILADELPHIA ELECTRIC COMPANY

was therefore necessary to design the brake for higher capacity.

As it was also necessary to be able to absorb relatively small powers at speeds higher than 3600 rpm, and any hydraulic dynamometer tends to become less stable at very small fractions of its normal capacity at any given speed, a compromise had to be made. Therefore, it was decided to design the brake for a limited capacity of 30,000 hp at 3600 rpm, or 3750 hp at 1800 rpm.

A cross-section drawing of the brake is shown in Fig. 1, in which it is seen that the casing is carried on roller bearings *K* to permit the torque to be registered on a weighing scale. Water to the brake is admitted through the two valves *A* and is discharged through the valve *B* and the two branches *C*, carried by the brake casing. The branches *C* discharge the water parallel to the center line of the shaft into the two drain pipes. The inlet water is supplied through a flexible hose connection so that there is no reaction from the water supplied either on the inlet or discharge. Only the reaction due to torque transmitted is weighed on the scales.

At its central portion, the rotor of the brake has a disk with pockets *DD*, while the stationary member contains blade rings having the pockets *EE* to which water is supplied through the passage *F*. Oil for the rotor-shaft bearings, mounted in the casing, is supplied as shown in the left-hand bearing through the passage *H*, controlled by a needle valve *I*. Oil enters the bearings through and escapes from the top of the bearing into a circumferential passage *L*, shown in the right-hand bearing. It is carried around the bearing and discharged through the drains *M*, as indicated. The supply and drainage systems are thus shown separately because the drawing would have been unintelligible had both systems been shown on both bearings.

To prevent water getting into the oil and also to prevent air getting into the water brake at light loads, two carbon rings adjacent to the rotor at each end, with water supply between them, act as a seal. Leakage from these seals is prevented from getting into the oil by a collar on the shaft, having milled radial slots acting as a thrower, which discharges to the drain shown as *O*. In addition, there are two slingers on the shaft, separated by drain spaces, also connected to the common drain *O*.

JOURNAL BEARINGS OF SPECIAL DESIGN

It will be noted that the shaft journals are of unusual construction. This design was provided for the reason that, as the brake is intended to operate at variable speeds and since the hydraulic forces in the brake are very large compared with the weight of the brake rotor, a slight radial displacement of the rotor can produce large hydraulic forces on the shaft. Consequently, the load on the bearing is not necessarily downward but may be in any direction; also the lubricating system must be such as to be equally effective in either direction of rotation.

The design, suggested by R. Marsland, involves the use of viscosity grooves which divide the journals into a number of equivalent segmental bearing sections, each of which is continuously supplied with oil throughout its revolution from the grooves in the shaft.

As the grooves in the journal are at an angle to the direction

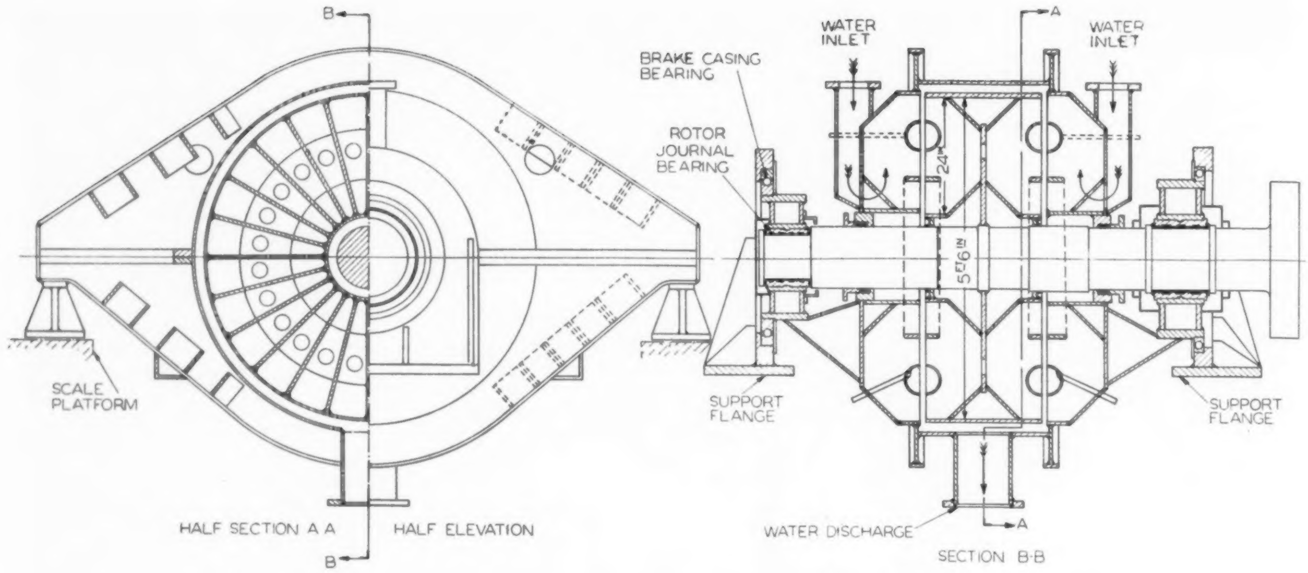

FIG. 3 WATER BRAKE OF FABRICATED TYPE, DESIGNED FOR A CAPACITY OF 64,000 HP AT 400 RPM

of rotation, the motion of the journal relative to the bearing surface brings into effect the viscosity drag of the oil, causing a flow through the channels formed by the grooves, resulting in a flow of oil from the center of the journal to the end, or vice versa, depending upon the direction of rotation. The oil discharged from the viscosity groove in the journal enters the circumferential grooves in the journal and in the bearing shell. As indicated in the cross section, Fig. 1, there are six axially drilled holes in the bearing shell, communicating with these circumferential grooves, thus permitting circulation from the center groove to the end groove and back through the bearing shell to the center groove, or vice versa, depending upon the direction of rotation of the shaft. Since the oil is put in at the bottom and removed from the top, the bearing and all the spaces are always completely filled with oil. The bearing at the left-hand side also has collars for taking the end thrust of the rotor and, more particularly, the end thrusts caused by differential expansions of the turbine and brake shafts and the frictional resistance of the flexible coupling to end motion.

Returning to the means of supporting the brake casing; rollers were used instead of ball bearings because experience has shown that the unavoidable vibration, which is bound to exist in such a structure not rigidly supported, causes the balls to wear small pockets into the races. This creates errors in weighing and, in particular, makes the dead weight extremely difficult to establish. It is possible to rotate the outer race of the supporting ball bearings in opposite directions continuously in order to eliminate the possible resistance due to rotation. However, it seemed desirable to avoid the necessity of having to provide rotating means and yet eliminate the pocketing of the balls, so rollers were decided upon, of such diameter and length that the load is sufficiently low to avoid such undesirable conditions. So far, although the surface of the brake cylinder and the supporting end brackets are not hardened, no noticeable signs of pocketing have been observed. The construction has the further advantage in that it makes a more compact arrangement and is considerably cheaper than the large ball bearings, designed especially for this purpose.

The brake, as installed on the blade-testing unit at the Schuylkill plant of the Philadelphia Electric Company, is shown opened up in Fig. 2, in which the parts previously described are easily recognized. It will be noted that the bolting is relatively heavy. The reason for this is that the pressures which may be developed in a hydraulic brake at high speed are likely to be very great. While, for the normal load which the brake is expected to carry, the pressure in the cylinders will rarely ever exceed 500 psi, it is possible that if, for instance, through some accident, the turbine started to run away and the water were admitted suddenly in order to stop it, the brake might momentarily be filled with water at high speed, in which case the pressure might rise to 2000 psi or even more.

FABRICATED BRAKE DESIGNED FOR 64,000 HP

The casing for the brake just described was machined from a solid forging as the most reliable and simplest method of making a single brake. A totally different type of construction mechanically is shown in Fig. 3, which illustrates one of the larger brakes used for shop testing. It will be noted from the construction that this brake is entirely fabricated. There are no castings used in any part of the construction. This brake has a capacity of approximately 64,000 hp at 400 rpm, when completely filled with water. Because of the enormous torque developed, stiffeners in the form of 4-in-diam standard iron pipe cut in half were welded into the moving and stationary members, as shown. It will also be noted that there are four pipes indicated coming out from the pipe stiffeners. These are to allow for the escape of air and to permit the brake to fill up completely with water at low speeds. At high speeds, except when the brake is completely filled with water, air enters these holes, unless the valves are closed, since the turbulence of the water in the brake passages is such that air is entrained and a vacuum exists in this central space. Due to the failure of three or four blades, because of pieces cracking out of them from vibration, it was necessary to add the stiffeners indicated in Fig. 3 and the corresponding rings in the rotating part. These are $^3/_4$ in. $\times$ 4 in. and $^3/_4$ in. $\times$ 3 in., respectively.

It will be noted from the arrows that the water is admitted somewhat differently in this brake than in the Philadelphia Electric brake. In addition to the brake just described, the South Philadelphia Works also has a larger brake with a 9-ft-diam rotor for testing slow-speed geared turbines. This brake has a capacity of 20,000 hp at 120 rpm when completely filled with water. In all cases, of course, it must be understood that an increase or a decrease of capacity from the figures, given with the brake completely filled with water, varies as the cube of the revolutions per minute.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

What Is a Profession?

THE ENGINEERING JOURNAL (E.I.C.)

ADDRESSING the annual dinner, Hamilton, Ontario, Feb. 7, 1941, of The Engineering Institute of Canada, William E. Wickenden, fellow A.S.M.E. and president Case School of Applied Science, chose for his theme "The Second Mile." In the address, which will be found in *The Engineering Journal* for March, 1941, Dr. Wickenden explained the title he had chosen by means of the Biblical quotation, "Whosoever shall compel thee to go one mile—go with him twain," by saying, "Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftsmanship, its code of man-to-man relations, which one must cover if he is to survive. Beyond that lies the mile of voluntary effort, where men strive for excellence, for unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the significance of a profession." It is to the question of engineering as a profession that Dr. Wickenden's address was directed.

Of professions there are many kinds; open professions like music, to which any man may aspire within the bounds of his talents, and closed professions like medicine which may be entered only through a legally prescribed process; individual professions like painting and group professions like law, whose members constitute "the bar," a special class in society; private professions like authorship and public professions like journalism; artistic professions like sculpture and technical professions like surgery; ameliorative professions like the ministry and social work and professions which achieve their ends by systematic destruction like the army and navy. Despite all these differences of pattern, there are characteristic threads which run like a common warp beneath the varying woof of every type of professional life and endeavor.

If one seeks definitions from various authorities, he finds three characteristic viewpoints. One authority will hold that it is all an *attitude of mind*, that any man in any honorable calling can make his work professional through an altruistic motive. A second may hold that what matters is a certain *kind of work*, the individual practice of some science or art on an elevated intellectual plane which has come to be regarded conventionally as professional. A third may say that it is a special *order in society*, a group of persons set apart and specially charged with a distinctive social function involving a confidential relation between an agent and a client, as the bar, the bench, and the clergy. Another source of confusion arises from the fact that some define a profession solely in terms of ideals professed, others solely in terms of practices observed, and still others in terms of police powers exercised. All authorities recognize that some of the distinguishing attributes of a profession pertain to individuals, while others pertain to groups, but there is considerable variation in the emphasis given. Let us glance briefly at these two sorts of distinguishing attributes.

What marks off the life of an individual as professional? First, I think we may say that it is a *type of activity* which is marked by high individual responsibility and which deals with problems on a distinctly intellectual plane. Second, we may say that it is a *motive of service*, as distinct from profit. Third is the *motive of self-expression*, which implies a joy and pride in one's work and a self-imposed standard of workmanship—one's best. And fourth is a *conscious recognition of social duty* to be accomplished, among other means, by guarding the standards and ideals of one's profession and advancing it in public understanding and esteem, by sharing advances in professional knowledge, and by rendering gratuitous public service, in addition to that for ordinary compensation, as a return to society for special advantages of education and status.

Next, what are the attributes of a group of persons which mark off their corporate life as professional in character? I think we may place first a *body of knowledge* (science) *and of art* (skill), held as a common possession and to be extended by united effort. Next we may place *an educational process* of distinctive aims and standards, in ordering which the professional group has a recognized responsibility. Third in order is a *standard of qualifications*, based on character, training, and competency, for admission to the professional group. Next follows a *standard of conduct* based on courtesy, honor, and ethics, to guide the practitioner in his relations with clients, colleagues, and the public. Fifth, I should place a more or less formal *recognition of status* by one's colleagues or by the state, as a basis of good standing. And finally *an organization* of the professional group based on common interest and social duty, rather than economic monopoly.

The public wisely puts the burden of guaranteeing at least minimum standards of competency on the profession itself. It may implement this obligation through public examinations and licensure, or it may entrust it to a system of certification within the profession itself, but in the end it comes down to the same thing—a profession must guarantee to the public the competency of its practitioners. In return, the public protects the profession from the incompetent judgment of the layman by a privileged status before the law.

Professional status is therefore an implied contract to serve society, over and beyond all duty to client or employer, in consideration of the privileges and protection society extends to the profession. The possession and practice of a high order of skill do not in themselves make an individual a professional man. Technical training pure and simple, I think we can agree, is vocational rather than professional in its character. The difference between the two is not merely a matter of length or one of intellectual levels—it is rather a matter of spirit and ideals and partly an educational overplus beyond the minimum required to master the daily job. This overplus must be sought largely through foundation studies which give a deeper insight into underlying principles and relations than the mere mastery of technique requires.

Through all professional relations there runs a threefold thread of accountability—to clients, to colleagues, and to the public. Is business a profession or can it be made so? We sometimes hear it referred to as the oldest of trades and the newest of professions. It seems clear that business is moving away from the dog-eat-dog area to one nearer the fringe of professional life. This occurs when the direct management passes from the hands of proprietors to a distinct administrative caste, with little immediate stake in the profits of trade. Business may still be far from a true profession, but management is

well within the pale. Business has lived traditionally from balance-sheet to balance-sheet; the time span of its thinking has often been about three months; the profit-and-loss statement has been its only yardstick. Professional managers, if assured of reasonable security of tenure, are better able to think and plan in terms of long-range prosperity and to act as responsible middlemen between investors, workers, customers, and the public. At one time I worked for the Bell Telephone System, of which no individual owns as much as one per cent. It is the best example of manager-operated, as distinct from owner-operated, business that I know of and the one that comes nearest to fulfilling professional standards.

All of us can take pride in this example, because it is so largely an engineer-managed enterprise. If we were to narrow our professional fellowship so as to include only men who render technical service on an individual agent-and-client basis and exclude all whose work is primarily administrative, I feel that we should do an irreparable injury both to ourselves and to society. The engineer has been the pioneer in the professionalizing of industry, and his task is only begun. Organized labor, it seems, is intent upon gaining a larger voice in the councils of industry; it wants to sit in when policies are made and to share in planning the schedules of production. This may be its major strategy for the defense period; witness the Knudsen-Hillman partnership in Washington and the Reuther plan for aircraft production by the automobile industry. If any such day is ahead, the middleman of management who can reconcile the stake of the investor, the worker, the customer, and the public is going to be the keyman on the team. For that responsibility, the finger of destiny points to the engineer. This makes it all the more urgent that the young engineer, while seeking in every way to gain a discriminating and not unsympathetic knowledge of the labor movement, should avoid being sucked into it by the lure of a quick gain in income and in bargaining power.

The ethical obligations of a profession are usually embodied in codes and enforced by police powers. The physician and lawyer are bound by explicit obligations and woe betide the man who oversteps them. As engineers, our codes are more intangible, as our duties are less definable. In any case, the obligations of a profession are so largely matters of attitude that codes alone do not suffice to sustain them. Equal importance attaches to the state of mind known as professional spirit which results from associating together men of superior type and from their common adherence to an ideal which puts service above gain, excellence above quantity, self-expression above pecuniary incentives, and loyalty above individual advantage. No professional man can evade the duty to contribute to the advancement of his group. His skill he rightly holds as a personal possession, and when he imparts it to another he rightly expects a due reward in money or service. His knowledge, however, is to be regarded as part of a common fund built up over the generations, an inheritance which he freely shares and to which he is obligated to add; hence the duty to publish the fruits of research and to share the advances in professional practice. If the individual lacks the ability to make such contributions personally, the least he can do to pay his debt is to join with others in creating common agencies to increase, disseminate, and preserve professional knowledge and to contribute regularly to their support.

There are too many engineers with a narrow and petty attitude on these matters; mature men who complain that the immediate, bread-and-butter value of the researches and publications of a professional society are not worth the membership fee, and young men who complain because it does not serve them as an agency of collective bargaining. Shame on us! Do we look with envy on the high prestige of medicine and of surgery? Then let us not forget that this prestige has been won not merely through personal skill and service, but through magnificent contributions to human knowledge without profit to the seekers and with incalculable benefits for all mankind. Do we covet public leadership on a par with the legal profession? Then we do well to remember that the overplus which differentiates a profession from a technical vocation calls for personal development and for powers of expression sufficient to fit a man for a place of influence in his community.

Measured by the standards I have been seeking to outline, many men who call themselves engineers and who are competent in accepted technical practices can scarcely be said to have attained a real professional stature. These are the men who have let their scientific training slip away, who do not see beyond the immediate results of their work, who look on their jobs as an ordinary business relationship, who contribute nothing to advancement by individual or group effort, and who have little or no influence in society. They have been unable to surmount routine in the early stages of experience and have gradually grown content with mediocrity. There is much in the daily work of a physician, a lawyer, and a minister of religion which compels him to be a lifelong student. In peacetimes the army officer is likely to spend one year in six going to school. The student habit is less often a mark of the engineer, which is natural perhaps in a man of action rather than one of reflection, but far too many seem to leave all growth after their college days to the assimilation of ordinary experience, without deliberate intellectual discipline of any kind.

There is a certain school of thought which has two quick and ready remedies for all ills and shortcomings of the profession. One is to keep the boys longer in college and to compel them to cover both the arts and the engineering course; the second is to compel every engineer to take out a public license. One need not quarrel with either the aims or the means; so far as they go both are good, but they cover only the first mile. Registration, I believe, will always be a qualifying standard rather than a par standard for the engineering profession. It will go far toward keeping the wrong men out, but will serve only indirectly to get the right men in. Beyond it lies a second mile of growth and advancement for which effective stimuli, incentives, and rewards can be provided only within the profession itself. The riper experience of the medical profession seems a safe guide. For the protection of the public, the law determines who may practice general medicine; but if a registered physician wishes to qualify as an orthopedic surgeon, he submits to a training prescribed by a voluntary group of specialists and undergoes an examination at their hands rather than those of a public licensing board. Evidences of distinction are likewise a gift within the sphere of the profession's inner life, rather than the domain of law.

I am encouraged by these trends to end on a note of prophecy. You are fighting a technological war, and we are entering upon an all-out program of technological defense in which every man under arms must be backed by more than a dozen in industry and in which only one man in four under arms is expected to carry a rifle. This experience is likely to have a profound effect on education. Within a decade we are likely to see technological education, both at the secondary and the higher levels, becoming more and more the dominant type.

The climax of man's effort to subdue nature, shift labor from muscles to machines, to make material abundance available for all, and to abolish poverty and disease, may well fall in the next fifty years. After that human interest may shift from work to leisure, from industry to art. Meanwhile engineers will multiply, research will expand, and industry will grow more scientific. Engineers will find their way into every field where science needs to be practically applied, cost counted,

returns predicted, and work organized systematically. They will be called upon to share the control of disease with physicians, the control of finance with bankers, the bearing of risks with underwriters, the organizing of distribution with merchants and purchasing agents, the supplying of food with packers and purveyors, the raising of food with farmers, and the operation of the home with housewives. In few of these new fields, if any, will engineers be self-sufficient; to be useful they must be teamworkers; and they must be prepared to deal with "men and their ways," no less than "things and their forces."

The engineering profession will exercise a far greater influence in civic and national affairs. It will probably never be able to define its boundaries precisely, nor become exclusively a legal caste, nor fix a uniform code of educational qualifications. Its leaders will receive higher rewards and wider acclaim. The rank and file will probably multiply more rapidly than the elite, and rise in the economic scale to only a moderate degree.

Engineering education must break away from its present conventional uniformity. At one extreme, a part of it must become more profoundly scientific; at the other extreme, a vast development of practical technical education for directing production will be in demand. Engineering schools ought to be less alike, less standardized by imitation. The men who are to lead the profession will need a longer training, and one that is both more broadly humanistic and more profoundly scientific. Great numbers of workers in technology could do well with a more intensive type of training. For every *one* who should receive postgraduate training, possibly *four* would find the present course sufficient, and *ten* would find an intensive two-year course more suitable. The science of economy needs to be more strongly emphasized at all levels. A science of human work needs to be created and systematically taught.

The engineer's job will be so varied, and will change so fast, and his tools will so increase in variety and refinement with the advance of science, that no engineer can hope to get a once-and-for-all education in advance. We must expect to re-educate engineers at intervals throughout their careers. The most important development of all may come in after-college education. In the future we shall see large numbers of young engineers, coming back to college, some for full time, some for half time, some in the evening, some in correspondence divisions; some to pursue higher work in science, some for new engineering technique, some for training in economics and business, and not a few for broader cultural opportunities. This is as it should be. We should cease to think of education as a juvenile episode. Once these means of adult education are provided in ample degree, the engineering colleges could broaden the scientific and humanistic bases of their curricula, cut down on early specialization, relieve overcrowding, inspire independent work, and show the world the best balanced and best integrated of all modern disciplines.

Automatic Shell Machines

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION

THE machine-tool industry, working through the Defense Committee of the National Machine Tool Builders' Association, has designed a line of special machines for the making of shell. The purpose of the project, undertaken at the suggestion of Army Ordnance officers, was to put into the hands of the War Department complete and tested designs for shell machines that could be built quickly in any well-equipped manufacturing shop whenever the need for them arose.

By making it possible for plants not otherwise engaged in the defense program, such as those manufacturing printing presses and textile machinery, to build shell machines, the machine-tool industry has broadened the source of supply and at the same time has freed itself to a greater extent to concentrate on the production of equipment for aircraft engines, tanks, guns, and other items that require precision machine tools. Though shell manufacture is important, it is not a precision job. The closest limit on a shell is five thousandths of an inch and most limits are from 20 to 30 thousandths.

With the defense program shifting into high gear, this line of shell machines is now in production.

The design comprises a complete line of machines for turning, boring, and facing medium-caliber shell. The machines are of two sizes—one for the 3-in. group of shell, the other for the 6-in. group, Fig. 1. In each group there is a basic machine that is standard for all of the operations in that group. Each unit is then equipped with whatever slides, tailstock, tooling equipment, and motor drive are required for a certain operation. The machines are capable of all operations except cross drilling, notching, and such operations as nosing-in, squeezing the band into the band seat, and welding the base end plate.

The engineering work was done under the direct supervision of Myron S. Curtis, consulting engineer in machine design.

There are three outstanding features about the new machines: (1) They are of simple construction so they can be built quickly in substantial quantities; (2) they are inexpensive and can produce shells economically; and (3) they are automatic so they can be handled by unskilled operators.

To make the building of the machines as simple as possible, the design completely eliminates all large planing and boring operations and all machining operations, large and small, on the main casting, except for the drilling of a few small holes. This is accomplished by supporting the carriage for the turning tools as well as the swinging arms for facing operations entirely on longitudinal bars instead of planed way surfaces, Fig. 2. Moreover, these bars (there are three of them) together with the spindle, tailstock sleeve, and all shafts, are carried by bushings which are cast in place in the main base of the machine.

The casting-in-place of bushings is accomplished by use of a pouring fixture, Fig. 3, for locating and supporting the bushings on pilot bars, and the use of a low-melting-point lock-in metal. The base of the machine has pouring holes cast in it, and in some cases two bushings are poured through the same hole. The recommended pouring metal is a lead-zinc, high-bismuth alloy which expands slightly upon cooling.

In addition to the bushings supporting all shafts, the seat upon which the cover plate rests is also made of this alloy. The metal is poured in a trough on the top of the headstock of the machine and allowed to find its own level. The cover plate, which also serves as a support for the motor, is then fastened to the base casting upon this seat. All doors and plates are attached to the rough base casting by cap screws. Neoprene gaskets are used with doors and plates to insure oil-tight joints, as the door seats are not machined.

The machines are all single-speed units except in cases where two-speed motors are used. The motors vary from 10 to 60 hp, depending upon the operation to be performed.

The main drive of the machine is from the motor, mounted on top of the headstock, through V-belts to a drive shaft then through a jack shaft to the spindle. The drive to the feed mechanism is through a chain and sprockets to a set of pick-off gears, then through a shaft to a feed worm and gear. This gear drives a drum cam for reciprocating a sliding bar on which the turning carriage is located, as well as face cams for operating the

facing arm and the bar for supporting and oscillating the turning carriage.

A constant-speed, individual motor is belted to the feedbox for rapid traverse of the tool carriage. Certain of the tool

FIG. 1 N.M.T.B.A. AUTOMATIC SHELL MACHINE—6-IN. LINE

blocks are slidable in the tool carriage. These are controlled by a stationary cam bar. The spindle and all of the shafts run in plain bearings. There is a ball thrust bearing on the

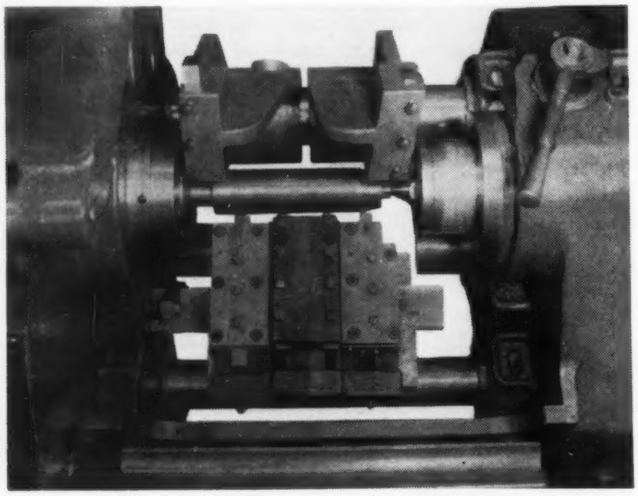

FIG. 2 TOOLING SETUP FOR 75-MM SHELL FOR SIMULTANEOUSLY ROUGH-TURNING DIAMETER AND FACING END

spindle as well as on the feed-drum shaft. These bearings are bronze, with a lining of Babbitt metal about 30 thousandths thick.

The machine has a live tailstock center which is moved longitudinally by hydraulic pressure. The valve for controlling this hydraulic movement is operated by the binder lever. But one movement of the lever is therefore necessary to move the center into position and to clamp it. Likewise, the reverse movement of this lever both unclamps the tailstock and removes it from the work.

There are two principal methods of holding the shell: (1) Gripping it on the inside of the open end by means of an expanding arbor, while using the tailstock center for supporting the base end of the shell; and (2) gripping it on the outside diameter by means of a collet chuck. In either case the shell-holding mechanism is hydraulically actuated, and control is by means of foot levers, in order to leave the operator's hands free.

It is intended that one central hydraulic system, with accumulator and tank, will serve a complete line of the machines, to avoid the greater expense of a self-contained hydraulic system for each machine.

Lubrication of the machine is by gravity from a trough cast in the top of the base and from which oil pipes lead to the various bearing surfaces. The oil settles in a sump in the base of the headstock, from which it is pumped by a separate motor-driven unit through a strainer and pressure valve back to the

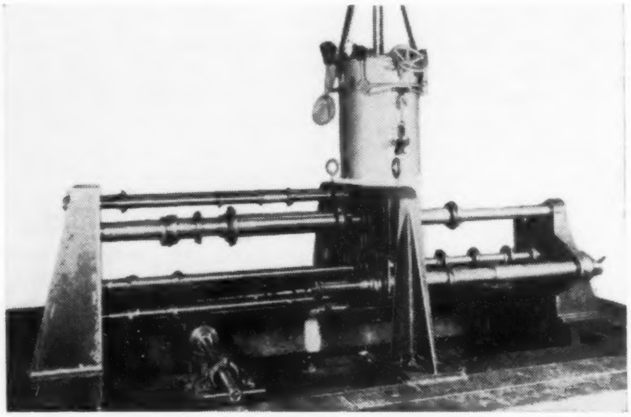

FIG. 3 POURING FIXTURE FOR LOCKING BUSHINGS IN BED

oil trough. The pressure switch consists of an electrical unit so connected with the control system that none of the operating motors, with the exception of the lubricating-pump motor, can be started or operated unless there is sufficient pressure on the lubricating system.

It is intended that coolant be supplied a line of machines by gravity from a central tank, the coolant from the machines being pumped back to the tank from a collecting sump. The central system would serve two purposes—reduce costs and keep the coolant at a much lower temperature than would be possible otherwise without requiring tremendous quantities of coolant.

Electrodirected Protection

INDUSTRIAL BULLETIN, ARTHUR D. LITTLE, INC.

NEW waxy coatings with electrochemical properties are claimed to offer more effective rust protection than the usual heavy slushings of grease on new machinery and other finished metal surfaces, according to a brief article in the February issue of the *Industrial Bulletin*, of Arthur D. Little, Inc. The so-called "polar" ingredients present in the new coating search out areas susceptible to corrosion, or where corrosion has started, and attach themselves, resisting further attack. The preparation is claimed to protect iron, steel, copper, aluminum, and magnesium, and their alloys.

When metals are wetted by salt water or other electrically conducting liquid, some portions are more susceptible than

others to attack. These vulnerable areas are anodic or positive, while the more inert areas are cathodic or negative. When water connects the positive and negative areas, an electric current flows that accounts for much of the corrosion. Some grease-like compounds, as for example the fatty acids, may have polar ends to the molecules, which are negatively charged by contrast to other parts of the molecule. These negative ends are electrically attracted by virtue of their charges to the positive, corrosion-vulnerable areas of the metal, cover the surface, and shut out water and further corrosion. The more salt or other electrolyte in the water, the better the protection afforded the metal.

A series of patented compounds has been developed for the production of protective polar films for use under various conditions. One soft, nondrying composition is for use indoors; another, of heavier consistency and semidrying, is for outdoor service; a third one is a dewaterer for the production of temporary films for salvage work; and a fourth is for cleaning and rustproofing of new metal. All are grease-like materials dissolved in a solvent, such as naphtha or trichloroethylene, and the compositions may be sprayed, brushed, or scrubbed on metal, or the metal may be coated by dipping. The coating produced is thin and transparent, but is claimed to be better protection than heavy smears or most slushing greases, which sometimes hide the metal and allow rusting to occur underneath. The coatings can be removed with kerosene or even with lubricating oil. For most purposes, once applied, they may be forgotten and the machinery merely be put into action when desired. Protective compositions of this type have found wide usage for turbines and Diesel engines, especially in marine work.

Gas Engine Use by Industry

AMERICAN GAS ASSOCIATION

In order to gage the growing interest on the part of industry in power development by operating internal-combustion engines on natural-gas fuel, the Gas Engine Power Committee of the Industrial and Commercial Section, American Gas Association, has conducted a survey of natural-gas utility companies serving fuel for engine consumption, which shows (1) twice as many gas-engine installations as existed four years ago, and (2) greatest development of the field among those enterprises where the smaller sizes of gas engines are adequate for their power requirements. Complete results of the survey are given in the 1940 Report and Gas Engine Census, published by the Committee and available through the American Gas Association.

The survey omits from consideration all gas engines operated by the gas companies themselves, and all engines which are installed on a temporary basis only.

One hundred and four companies responded to the survey, as against 14 which responded to similar queries in 1936. It was found that 56 of these natural-gas companies are now serving gas for engine operation, to the tune of 12,392,398,000 cu ft consumed in 7998 engines developing 474,629 hp for 4496 concerns, and resulting in an annual revenue to the 56 utility companies of $2,643,247. On a grand average, it was found that the average engine horsepower was 59; that 26,110 cu ft of gas were used per year per horsepower installed; and that annual gas-company revenue was $5.57 per hp.

Roughly 45 per cent of all this gas-engine business was served by eight natural-gas companies who reported in 1936 as well as in 1940. Hence it was possible to gage the growth of industrial interest in gas engines. For these eight representative companies, the number of engines connected has risen 98.6 per cent, the number of accounts 68.1 per cent, the total connected horsepower 40.8 per cent, and the annual revenue to the gas industry 89.6 per cent. The average horsepower per engine has dropped from 73 to 51.8, showing that most of the new gas-engine installations have been in the smaller sizes.

This year 22 engine manufacturers reported producing models for natural-gas fueling—a record number. The committee notes in this connection: "While many of these manufacturers have been in the business of manufacturing gas engines for many years, a large number are newcomers to the field. It is particularly significant that many of the manufacturers listed were originally Diesel-engine makers exclusively, and have only recently realized the potentialities of gas-engine business."

Continuing its investigations[1] of "high-temperature-cooling of gas engines" because of the "great possibilities along the line of waste-heat recovery coincidental to this method of engine operation," the Committee reports on 46 natural-gas engines (varying in size from 40 to 250 hp) which were observed over periods of from 12 to 18 months of operation at cooling-water temperatures from 215 to 230 F. These engines were periodically inspected during operation and subsequently torn down for detailed micrometer inspections. Further, dynamometer tests were conducted on engines equipped with conventional (160 F) cooling units, then rechecked after being cooled at 212 F. It is reported that: (1) Dependability has been as good in all cases, and in many instances better than engines operating at lower cooling-water temperatures, (2) oil consumptions have been no greater, (3) cylinder wear has been normal, and in some cases phenomenally low, (4) piston rings were entirely free and clean, (5) engine-head gaskets of standard materials have held perfectly in all cases, (6) bearings were in excellent condition, (7) condensation (water in oil sump) was entirely eliminated, and (8) dynamometer tests showed a slight increase in engine horsepower under full-load conditions with the same quantity of fuel, indicating possible reductions in "oil drag" at higher cooling temperatures.

As a result, the A.G.A. Committee feels that "it is now possible safely to advocate the use of high-temperature cooling wherever waste heat may be utilized to advantage in conjunction with the operation of a natural-gas engine." The advantages of waste-heat recovery through the "high-temperature-cooling" method are said to be: (1) The ability to recover approximately 50 per cent of the heat value of the fuel (in addition to the 25 per cent converted into useful work); (2) waste-heat recovery both from jacket water and exhaust gases without upsetting the balance in the engine cooling system or affecting the temperature differential in the engine itself, regardless of variation in operating conditions; (3) automatic compensation for fluctuations in external-heat demand or engine load, without either attention or adjustment by plant operator.

Barrel Engines

S.A.E. JOURNAL

In an article entitled "More Power From Less Engine," in the *S.A.E. Journal* for December, 1940, E. S. Hall, manager, The Round Engine Patents, says that two methods for achieving this objective are available—by improving current engines and by a new start toward a more promising type. For the

[1] Reported in the 1939 Report of the Gas Engine Power Committee of the American Gas Association.

lowest power-plant drag, he writes, use the barrel engine with cylinders parallel to the shaft.

Six barrel-engine mechanisms are appraised critically by Mr. Hall in order to find the best, which is also better mechanically than the crank mechanism. In a crosshead mechanism in which pistons cannot cock, top speed may be 15 per cent faster than with the crank for same combustion time, and there is almost no useless loading on bearings.

Of all combustion systems, according to Mr. Hall, the choice narrows to four-stroke Otto cycle or two-stroke Diesel. He gives specifications of a four-stroke gasoline engine, using current poppet-valve practice, capable of delivering 3000 hp at 3000 rpm, weighing 2700 lb, with 6 sq ft frontal area.

Limitations on cylinder size are all limitations of four-cycle or of crank and poppet-valve mechanism; larger cylinders are practicable with the two-stroke Diesel.

The opposed-piston type is only second best, in Mr. Hall's opinion. Best is the normal type with double-ended piston members, essentially double-acting, with piston inertia serving the flywheel function of offsetting peak cylinder loads to smooth the torque. Possible breathing systems are discussed and specifications are given for a two-stroke Diesel capable of development to deliver 5000 hp from 3000 lb with 7 sq ft frontal area.

Fog Investigations

JOURNAL OF THE AERONAUTICAL SCIENCES

THE Wright Brothers lecture of the Institute of the Aeronautical Sciences was delivered by Dr. Sverre Petterssen of the Massachusetts Institute of Technology on December 17, 1940, and was published in the *Journal of the Aeronautical Sciences* for January, 1941, under the title "Recent Fog Investigations."

Dr. Petterssen devoted the first part of his lecture to the physics of fog and a discussion of the meteorological conditions under which various types of fog may form. Included was a study of condensation, different types of air-borne nuclei of condensation, and the wide variance in their powers to attract moisture. Properties, characteristics, and sizes of various nuclei were described together with the condensation process and factors which control the colloidal stability of fog.

The problem of dissipating fog by artificial means above limited areas, such as an airport runway, was outlined, and several methods which have thus far proved impracticable were described.

In the second part of his lecture, concerning the meteorological conditions for the formation of fog, Dr. Petterssen discussed the conditions necessary for the forming of frontal fogs, caused by rain falling into warmer air, and steam fog or arctic sea smoke, observed when cold air streams over much warmer water. He also discussed the factors governing the formation of commoner forms of radiation, advection, and upslope fogs. The behavior of fog over snow-covered ground was described and a summarized classification of fog-producing and fog-dissipating processes concluded the paper.

In his discussion of the artificial dissipation of fog, a subject of interest in navigation both on the water and in the air, Dr. Petterssen said:

Although many unsuccessful attempts to dispel fog have been made, the potential utility of a practical method is great enough to justify a brief discussion of the problem. In general, fog may be dispelled either by the evaporation of the drops or by physically removing the drops from the air. The requirements for the evaporation of the fog drops may be readily evaluated. To evaporate the drops, it is necessary to supply the latent heat of evaporation and also to reduce the relative humidity of the air (as by heating it) so that the additional water vapor can be accommodated. In order to insure a reasonable rate of evaporation, it is usually desirable to reduce the relative humidity by an amount which is considerably larger than the minimum set by the liquid water content of the fog. A reasonable value for the desired relative humidity is 90 per cent. If the initial air temperature were 20 C and the liquid water content were 0.2 g per sq m, the total heat required to dissipate the fog would be 520 cal per sq m, of which only one fifth would be used to evaporate the fog drops, the remainder being required to reduce the relative humidity to 90 per cent. Since a certain amount of wind is usually present, fog must be dissipated continuously to maintain a clearing of suitable size. Assuming average fog conditions, Houghton and Radford found that the equivalent of 5000 kw would have to be supplied continuously to maintain a cleared volume approximately 40 m wide × 10 m high × 600 m long in the direction of the wind. If this power could be supplied by burning oil, the cost would not be excessive, but the computations assume a uniform distribution of heat, and this would be extremely difficult to arrange for. In any event, it is apparent that it would be impractical to clear large fogbound areas such as harbors and airports.

The evaporative dissipation of fog may also be accomplished if the relative humidity is reduced by allowing finely divided hygroscopic particles to fall through it. This method has been worked out in detail by Houghton and Radford, and a number of successful full-scale demonstrations have been made. A clearing of the size already suggested (40 × 10 × 600 m) was maintained in dense fogs with wind velocities as high as 16 mph by spraying 85 gal of a saturated aqueous solution of calcium chloride per minute.

Any field of force, which would cause the fog drops to coalesce into drops large enough to fall rapidly in the gravitational field, would represent an ideal means for the dispersal of fog. An intense sound field appears to be the only possibility in this direction, but computations indicate that it would not be practical in natural fog, although it has been used to precipitate aerosols such as smoke on a laboratory scale.

The fog may be precipitated by allowing a sufficient number of electrically charged (or uncharged) particles to fall through it. The falling particles collide with the fog drops and carry them to the ground. This method has been tried, using charged sand, with relatively unsatisfactory results. It is also possible to precipitate fog by passing it through a Cottrell-type electrostatic precipitator or through a baffle-like arrangement of fixed surfaces, but both of these methods require expensive and cumbersome apparatus.

Many other fog-dissipation methods have been suggested, but all of the feasible ones are modifications of one of those already mentioned, and their relative merit can be judged in the same manner.

Ratio Delay Study

1940 ANNUAL MEETING, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

DURING the last thirty years, no important improvement had been made in that fundamental part of time study technique by which is measured the time lost by unavoidable interruptions, delays, and variations incidental to the performance of any manufacturing operation, said Robert Lee Morrow, lecturer at New York University, in a paper presented at the Annual Meeting, Dec. 2–6, 1940, of The American Society of Mechanical Engineers.

About 1881, Fred W. Taylor invented and used time studies as we know them today. In computing these studies, he made allowances for unavoidable delays, as indicated in his paper presented before The American Society of Mechanical Engineers, in June, 1895. Taylor's method of taking and computing time studies was further developed by Dwight V. Merrick and Carl G. Barth.

Before any standards can be accurately set for cost purposes, wage incentives, scheduling, or planning, it is necessary to make allowances for delays incidental to the performance of work. Determination and evaluation of these delays is of the utmost importance in the computation of correct standard. Because of the variation in length and frequency of delays, their measurement is extremely difficult.

Any legitimate interruption, delay, or variation must be allowed for when a time study is computed for the purpose of establishing a time standard. In general, when these delays will occur is unknown and their length cannot be predetermined.

The analysis of delay studies may bring to light conditions hitherto overlooked or unknown, which have an important effect on the output of an operation or an entire factory. For this alone, such studies are invaluable.

Taylor's method consisted of studying all the operator's movements over a long period of time, using a stop watch, and noting particularly any and all delays and interruptions. These studies were taken on a number of operators doing the same or similar work.

In modern manufacturing there are so many other demands on the time-study observer that he finds it difficult to give his entire time and attention, over a period of weeks, to production studies. The result has been that such studies, while admittedly desirable, are postponed or entirely neglected, and delay allowances have too often been based on "judgment" alone.

In searching for a better way to determine delay and variation allowances, a method used by L. H. C. Tippett, in the English textile industry, described in the *Journal of the Textile Institute* Transactions, February, 1935, was put to practical tests in three separate industries, by graduate time-study students, under the direction of the Department of Administrative Engineering at New York University.

These studies, the results of which were reported in Mr. Morrow's paper, show the new method to be a statistical technique, highly practical, and productive of more accurate results at less cost than methods previously employed. As every operation, in every industry on which cost or wage-payment standards are set, must include the allowances mentioned, the importance of this new method is evident. The new method is called "ratio delay study."

In recording a ratio delay study, a large number of observations are taken at random intervals, recording whether or not a machine is operating. Then, as Tippett states, "the percentage number of readings that record the machine as working will tend to equal the percentage time it is in that state."

Likewise, if random observations are taken of the operator's cycle of work, "the percentage of readings recording the operatives as performing a certain operation or group of operations is an estimate of the percentage time spent in those operations."

If the readings "are randomly distributed over a sufficiently long time, this relationship holds whether the machine stoppages or operations of the operatives are short or long, many or few, regular or irregular."

The method Mr. Morrow and his associates employed and found satisfactory is to make each observation at the instant the observer reached a given point (for instance, when he was directly alongside the workplace) noting whether the operator is working, or if not, the cause of the delay. The reason it has been found desirable to take readings in this way is that this practice gives a definite recording instant.

When the operators were advised of the purpose of the study, they went about their duties as usual. As no stop watch is used, one of the operators' objections to time studies is eliminated.

Actual variations are bound to occur in machine output, operator's rate of work, and in the number and time of the delays and interruptions. Since the data collected are a sample, ordinary sampling errors will also occur, which may be considerably reduced by taking a large number of observations.

Chance errors of observation will occur, for, even if conditions are controlled and stabilized, the percentages of delay time found for one series of observations may vary from the next series and neither of these is likely to agree exactly with the true percentage, found from a vast number of observations.

These random variations should, as stated by Tippett, follow the binomial law. It is possible to measure approximately these variations by computing the standard error of a percentage.

Tests for conformity to the binomial law consist of seeing how the actual and theoretical variations, added together, compare with the random errors of observation.

Tippett describes the accuracy of results obtained in English textile mills: "Unless exceptional precautions are taken, the total error is not likely to be reduced much below about 2 per cent, except when the percentage measured is very high or very low (i.e., between 0 and 5 per cent and between 95 and 100 per cent), or comparisons are being made under conditions in which systematic errors are constant."

The following conclusions stated by Mr. Morrow are a summary of those arrived at by the three engineers who conducted the ratio delay studies cited in his paper.

1 Only homogeneous groups should be combined; such as delays on similar operations performed on similar types of machines, or delays of operators on work of a similar nature.

2 A large number of observations is recommended, and studies are best adapted to large groups of machines or operators. When the number of observations on the job was about 500, a fairly reliable result was obtained. Over 3000 observations gave very accurate results.

3 Results from a few hundred observations may be used, if the frequency distribution conforms to the binomial law.

4 The accuracy of results may be determined in any case.

5 As the percentage of delay time increases, more observations are necessary for a given accuracy.

6 Data are more reliable if the observations are taken over a long period of time.

7 Observations must be taken at random intervals and distributed over all hours of the day and week.

8 Intervals between samples must be sufficient to give independent readings.

9 The ratio delay study provides an opportunity to observe and evaluate operations of the department as a whole.

10 The observer's work may be interrupted at any time without affecting the study. Taking studies is not tedious for the observer.

11 There was no objection to ratio delay studies by operators, because no stop watch is used and the operators are not closely observed for a long period.

12 The cost of studies is about one third that of production studies.

Radiant-Heat Applications

ELECTRICAL ENGINEERING

BRIEF mention was made of the use of the radiant-heat energy from infrared lamps in the baking of enamel on metal surfaces in an abstract presented in the April, 1940, issue of MECHANICAL ENGINEERING, page 324. In *Electrical Engineering* for January, 1941, Paul H. Goodell, of the radiant division, C. M. Hall Lamp Company, Detroit, Mich., discusses more fully the use of radiant heat produced by incandescent lamps in drying, baking, dehydration, and other moderate-temperature applications. A section of the paper dealing with advantages and uses is quoted in what follows.

Numerous advantages may be cited for radiant energy heating in addition to the controlled rate of heat transfer. The high-temperature sources provide virtually an instantaneous source of heat, thus eliminating the customary warm-up time for convection ovens. Loss of heat during the warm-up period, as well as the consequent loss after each period of operation, also is eliminated. Because air temperatures are not raised to comparable convection oven levels, working conditions are frequently more comfortable. The elimination of fumes resulting from combustion fuels also contributes to improved working conditions and sometimes to more satisfactory results.

The first cost is invariably low, inasmuch as the structure may be limited to a skeleton frame without insulated walls, doors, or temperature-control equipment. Draft shields ordinarily are employed to minimize convection losses and, under some circumstances, exhaust hoods may be required above the ovens to remove objectionable fumes. Working temperatures consistently will follow the intended time-temperature response if proper maintenance, voltage regulation, and uniform air conditions are assumed. The semipermanent construction allows the utmost flexibility for plant changes, and the proper arrangement of electric circuits frequently makes for advantageous conversion of the oven to accommodate varying types or sizes of work. The lightweight construction also permits hanging ovens from the ceiling, allowing the free use of floor space below.

Since radiation can be controlled effectively, the energy may be directed or confined to a desired heat pattern or zone of operation. Commercial equipments are available providing various heat patterns so that the utilization efficiency may be of a very high order. This feature also makes possible the design of multiple-heat-density ovens so that the most effective heat concentration may be applied in each stage of a process and the total cycle consequently reduced to a minimum time. With convection practice this would necessitate sectionalized oven construction, at inherently greater cost.

The direct energy transfer without intermediate heating of steam or air not only facilitates high efficiency, but the increased rate at which temperature changes may be effected invariably provides substantial savings in time. Where heating operations are mechanized this simultaneously reflects a corresponding saving in space, thus facilitating automatic handling. Many industrial finishes today are being baked in less than two minutes, indicating that the proper combination of polymerizing materials and heat application may reduce the time for such baking processes to a small fraction of that characteristic in current practice.

While the source temperatures used in radiant heating are substantially higher than temperatures with combustion or other customary heat sources, the enclosed construction assures relatively low surface temperatures. With a second enclosing envelope employed for optical control and breakage contingencies, the resulting safety from fire or other hazards is of an extremely high order as compared with many other types of ovens.

The effect of humidity in a radiant-heat oven becomes practically negligible since the principal mass of air in the oven is at an appreciably lower temperature than that immediately in contact with the work. As a result the air goes through a continuous cycle of heating and cooling, absorbing the vapors when heated in contact with the work and allowing them to condense in colder portions of the oven. This affords a decided advantage for dehydration applications, as the convection losses may be reduced materially by a lower rate of air change than would be necessary with convection drying.

At present, radiant heat is being employed primarily for the low-temperature heating of metals and plastics, the baking of paints and insulating varnishes, and a great variety of dehydration operations. Plans are now in process for extending it into many other fields, particularly where chemical operations may be accelerated. Fuel costs may or may not be directly comparable, depending on individual conditions, as one or more of the other operating advantages may produce savings that will very well justify a far more extensive use of electricity in the field of low-temperature heating.

Few developments in the last decade have been so revolutionary or have offered such promise for future expansion of the electrical industry as this one which had its inception for production application in the plants of the Ford Motor Company. Due credit therefore is accorded to the work of that company and to the many people in the electrical industry who have cooperated in bringing this development forward to a place of respect as a significant tool for industrial use.

"RESEARCH"
(Photograph taken by George G. Hyde and shown at the Fifth Annual Photographic Exhibit held during the A.S.M.E. Annual Meeting, Dec. 2–6, 1940, New York, N. Y.)

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

What Every Executive Can Mobilize

FIRST of all, executives, from the top down to supervisor, must become clear in their own minds what it is that we need to mobilize. In America, machines and men are all available—mobilization in the sense of expanded output is, in the final analysis, a routine job on an expanded scale.

But we must also mobilize that spirit which will make men willingly put everything they have into their jobs.

We don't have to look to recent events for illustrations of the effects of the neglect of this force. We need only to consider the present low efficiency of our own industrial workers and the appalling failure of equipment maintained by them. The cost of these runs into unrecorded millions of dollars. In the present hysteria, the tendency is to attribute these factors to subversive forces, sabotage, accidents, etc. Serious as these disturbing factors may be, an even deeper trouble lies in the "Don't give a damn" attitude of a large number of employees.

The responsibility for the existence of this attitude and the initiative for the corrective lies with the executive. Sometimes the executive's only connection with his men is a push button instead of a friendly personal interest.

It is common knowledge that a good executive deals less and less with things and more and more with people. It seems obvious that if the employees are to be genuinely interested in working out the plans of the executives, that the executives first must be interested in the employees. Somewhere we have forgotten that the employee's efficiency is increased more by appreciation of him and his work than by salary increases.

How far downstream we have come in neglecting the human equation is illustrated in the experience of a Midwest industrial executive.

A strike had been called much to his surprise and resentment. Jim, the chief foreman, and one of his oldest and most trusted men, had gone out with the rest—Jim, with whom there had been the closest cooperation through his shirt-sleeve days.

This partner told his wife he could not understand why Jim should join "such" a movement. His wife said, "Why don't you ask Jim?" He replied, "I'll be damned if I will!" However, when he thought it over next day he decided differently. Jim showed him that when all the executive orders were put together they did not make sense. After study, this partner agreed and changed them. He realized that for the last five years he had been too busy to keep in touch with his men. The strike was settled and the men were back within a week.

Enlightened management has provided the workers with athletic and social activities, insurance benefits, vacations with pay, hospitalization, etc. Executives may wonder why their men seem to take for granted many of these things. They entail merely money and administration. Very often these are not the most important needs nor the desire of the workmen. It is fun to give presents that are desired by the one remembered. Why not try in the plant, as we do in our homes, to find out their wishes before we spend their share of earnings for their benefit?

If executives are in close touch with their men they can also avoid picking ill-adjusted supervisors. A poor supervisor seldom fools anyone who is in contact with him.

An executive I have in mind, ten years ago was in charge of a large department. Since that time his group has been absorbed into a large company and there has been a complete reorganization. It has been quite evident that men who served under the executive in question are those who today have merited and received the responsible positions in the new organization. Those who know this case agree that the one essential factor that made this possible was his genuine interest in his men. His was inspirational leadership.

If we look at what has been happening to our business world in the last few years, we find that business executives generally have been under such pressure of internal problems and so full of fear of taxes and governmental changes that they have kept their minds almost entirely on the problem of "things" instead of people.

On this whole question of human responsibilities before property rights may hang the survival of free enterprise. What is needed to distinguish industry from exploitation and paternalism is a philosophy of human cooperation that cares as well as shares. Without this philosophy business becomes a form of aggression and ceases to be free enterprise. Sooner or later it will meet the counterforce of outside control.

No one is quite sure just what lies ahead. But we do know that if we have built up loyal and working organizations they can be adapted in a moment's notice to whatever needs may come. Our only human security today is in men willingly cooperating on tasks which fit into a national plan. Our security is not in the money, material, and position that we have accumulated, but in the unselfish and patriotic productivity of each individual—productivity of equipment for defense and productivity of a fear-free national morale.

The obvious way for the executives to begin this mobilization is to stop thinking that they are too busy with things and show a genuine interest in the people for whom they are responsible. The real executive is the one who can deal with the needs of his men—spiritual as well as material. Only when these needs are filled can they produce at maximum the output that will be required from industry.

Without this foundation, "mobilization" will be only a word.

MURRAY F. SKINKER.[1]

National-Defense Planning

TO THE EDITOR:

A national-defense program requiring expenditures of billions of dollars should be preceded by a careful engineering study of defense needs. A program of promiscuously increasing armaments will mean a waste of money for the purchase of materials not needed and could conceivably be dangerous through neglect of needed materials.

After making as accurate an analysis as possible of the men and equipment of po-

[1] Consolidated Edison Company of New York, Inc.

tential enemies or combinations of enemies, an engineering investigating committee should consider, among other things, the methods an enemy could use in attacking the United States and the available transportation equipment. Knowing what the enemy could bring to bear against us, we could prepare programs of methods and equipment needed to most effectively combat the enemy. The defense program could then be rationally planned to give us the necessary equipment for any contingency.

If such an investigation should be made it would disclose that enough ships could not be gotten together to simultaneously transport enough men and equipment across an ocean to hold a base in the United States until reinforcements arrived. Such an investigation would also disclose that landing troops on our coast would be impossible without something worse than Dunkerque because aircraft carriers cannot carry enough airplanes to control the air, nor are exposed naval guns a match for hidden, emplaced coastal-defense guns. Incidentally, the much talked of invasion through South America would double the transportation distance from Europe.

In view of the comparative ease with which an invader could be repelled, it is folly to choke private business and to court inflation by spending enormous sums of money for excess "defense." Engineers are neglecting their duty to the country's welfare by encouraging the hysterical "preparedness" program instead of doing all they can to bring about a sane realization of the facts by the American people. Prominent engineers are helping to lay the basis for the future accusation that business led us into bankruptcy.

In addition to giving publicity to invasion difficulties, engineers may live up to their own moral obligations by refusing to participate in "total defense." However, that is becoming increasingly difficult because of the relative scarcity of plants that are not working on war orders and because of the attitude of the government that manufacturers should be forced to "cooperate."

WALTER F. GORMLY.[2]

World Calendar

TO THE EDITOR:

Referring to the "World Calendar" on page 908 of MECHANICAL ENGINEERING for December, attention is invited to my suggestion for avoiding terrible confusion during the transition period.

Abandon the months entirely and number the days through from 1 to 91 (or 92) for each of the four quarters (winter, spring, summer, and fall). Then if some still called this the first day of December, while others called it the sixty-fourth day of fall, there could be no confusion.

Or, with no change in the proposed calendar (only the nomenclature), this could be called the third day of the third fall month.

GILBERT S. WALKER.[3]

Cottonseed Research

COMMENT BY L. W. WALLACE[4]

This cottonseed-research project[5] is one of significance and value. This can be appreciated by those who grew up on cotton farms before the day of the cottonseed-oil industry. In those days cottonseed had little, if any, commercial value.

During the ginning season the ginners could not prevail upon the farmers to remove from their gin yards more than a small fraction of their cottonseed. As a consequence, an innumerable number of tons of seed were burned by the ginners as fuel in the generation of steam.

The development of the cottonseed-oil industry brought about a great change. Today cottonseed oil is used for many industrial and domestic purposes. This oil is an ingredient in many soaps, cooking compounds, and pharmaceuticals. As a result the farmer now enjoys an income from his cottonseed which is about 20 per cent of what he obtains for lint cotton.

Thus, research and development work have converted a former farm waste into a useful commercial product.

The work of Professor Morton and his associates is extending the commercial uses and value of cottonseed. He tells us that now it would appear that even cottonseed hulls may be used in the making of plastics. Thus, the processes of research are further extending the utilization of a former farm waste.

The results thus far obtained clearly demonstrate what splendid accomplishments may be realized through the cooperation of research, industrial, and agricultural agencies. It is hoped that this demonstration may serve to stimulate many other like cooperative programs. If this comes to pass, the industrial, agricultural, and economic well-being of all concerned will be enhanced and society at large greatly benefited.

Encouraging Creative Ability

COMMENT BY R. B. DALE[6]

This paper[7] gives us much food for thought. What are the fundamental steps which lead to creative thinking? The authors emphasize imagination and the imaginative mind. Without doubt, this is significant. Imagination springs from experience. Creative thought starts from the known, the physical, and the concrete experience and projects into the unknown and, as yet, unexperienced domain. The authors speak of this quality as "creative intuitive ability" and recognize it as a rare accomplishment.

Intuition is knowledge that comes from within. It is perceived by the mind instinctively and without the intervention of the thought process. It is the ability to respond to a situation immediately and without conscious reflection.

While it is difficult to diagnose the qualities of the creative mind to the point of putting first things first, may it not be true that interest and curiosity, a questioning attitude, deserve a place near the head of the list? "What makes it work? What would happen, if —? How can it be done? Why do it this way? What is the easiest and simplest way?"

The authors make another statement of interest when they say that "the really ingenious designers of today are men who have come up through the shop and drafting room, possessing a wealth of first-hand experience with mechanisms and manufacturing processes." This is, indeed, appropriate recognition of the importance of concrete experience.

It would seem that the quality of alertness or awareness should also be given a place near the head of the list. It is not enough to take a passive position, if one is to develop creative ability. One should cultivate those habits of observation which invite mental activity. Alertness establishes a mental image which may be drawn upon in the future. Experiences which count are accompanied by an awareness which associates cause and effect.

The power of creative thinking and originality is an outgrowth of concrete experiences and the ability to project the thought by synthesis, analogy, and intuition over the threshold of the commonplace. This leads to speculation but,

[2] Milwaukee, Wis. Jun. A.S.M.E.

[3] Pittsburgh, Pa.

[4] Director of Engineering and Research Division, Crane Company, Chicago, Ill. Mem. A.S.M.E.

[5] "Cottonseed Pressure-Cooking Research," by R. W. Morton, MECHANICAL ENGINEERING, vol. 62, October, 1940, pp. 731–735.

[6] Head of the Department of Industrial Management and Mechanical Engineering, School of Science and Technology, Pratt Institute, Brooklyn, N. Y. Mem. A.S.M.E.

[7] "Encouraging Creative Ability," by A. R. Stevenson, Jr., and J. E. Ryan, MECHANICAL ENGINEERING, vol. 62, no. 9, September, 1940, pp. 673–674.

without doubt, something more than speculation is necessary.

Along with this quality of speculation goes aggressiveness, a will to dare, an urge to give form and reality to an idea. One must also have the courage to overcome obstacles. Modern procedures call for delineation on paper before construction is undertaken. This demands ability to plan, to synthesize, and of course to simplify. It is at this point where discouragement is to be met. Too few are sufficiently persistent to carry on the labor requisite to produce practical results. They give up and quit before the idea has had a chance to grow into practical form. Would it seem reasonable to state that maturity of judgment, not necessarily maturity of years, is one of the requirements?

Without wishing to appear authoritative, may we now venture to form a list of subjective qualifications for the creative mind? Perhaps by attempting to do so, we may challenge our friends, the psychologists, to offer us some help. Such a list might be: (1) Interest and the questioning attitude, (2) alertness, (3) imagination (speculation), (4) intuition, (5) the ability to synthesize, (6) concrete experience, (7) ability to project the thought, (8) planning or visualization, (9) aggressiveness, (10) persistence, and (11) maturity of judgment (common sense).

So much for subjective conditions for creative thinking. What about objective conditions?

What is the effect of environment? We are led to believe that technological advances do not come suddenly. They, in common with other social advances, spring from human needs and changing social habits. The need furnishes the incentive. Often we are tempted to think of revolutionary invention in relation to environment as a result of chance circumstances, but more careful analysis generally reveals that the need and even the means have been made evident by thoughts and habits which have existed for a considerable period of time. Perhaps it is because of this fact that we recognize that an invention must be timely.

If the environment sets the need and provides the means for technological advances (invention), it also establishes disciplines. It demands that such advances shall be orderly and practical. Physical laws set physical disciplines, and the social and economic order demands social disciplines. Such advances, to be acceptable, must conform to these disciplines. This requirement goes beyond theory and speculation; it is pragmatic. The decision as to what character and utility invention shall take is determined by human desires, wants, and necessities. Management or business decides in a large degree what and when to invent; at least this appears to be true in the social and economic world in which we live. The environment must be favorable.

Technological advances are seldom the exclusive product of any single mind acting independently. As education becomes more widely spread and as significant experiences become more common, technological advances are accelerated. Many people contribute to the process of invention or, to speak in more general terms, many people contribute to the process of creative thinking in any and all phases of life. Industry and technology, within their own realm, have become aware of this. Constructive and progressive action is multiplied by the combined or joint effort of engineers supported by management. The cost of research and development of practical invention is so great that the lone inventor, working as an individual, is faced by a difficult situation.

If now we attempt to list the objective factors in technological advance, we might have the following items: (1) Social needs and changing habits, (2) incentive, (3) timeliness, (4) physical and economic disciplines, (5) favorable environment, (6) joint effort, and (7) support of management.

The authors state, "Most people concede that the creative flair (subjective factors) must be born in a man but it remains for schools and colleges to detect this undeveloped ability, and give it proper exercise and encouragement (objective factors)." Words in parentheses are the commentator's.

Unfortunately, it is difficult for the colleges to provide an environment favorable to the development of creative thought. The college is successful in aiding the student to improve his maturity and to add to his experiences. The main purpose of the school, especially in the four-year undergraduate course, is to instruct. The teaching techniques of imparting information and aiding understanding are quite distinct from those techniques which would most effectively encourage and develop the creative mind. In the process of informing, the student follows the text and the leadership of the teacher. The body of technical and scientific knowledge is so large and varied, and the conventions of scientific procedures are so involved in abstractions, that there is hardly sufficient time to cover the field comprehensively. Educators are concerned in establishing a broad base from which the young engineer may have an adequate take-off in one of the numerous fields of activity into which chance or design may lead him in his future career as a practitioner. There is no way of knowing in advance what direction his activities may take. Hence, emphasis is on generalizations and accepted formulations rather than toward specific cases. This undertaking, in itself, represents a task of considerable magnitude.

The generally accepted methods of group instruction in classes and the measurement of accomplishment by rating the student in comparison with the progress of the class in formalized procedures tend toward establishing a pattern. If the student deviates from this pattern, he is likely to get a low scholastic standing.

The school emphasizes individual effort as contrasted with the type of joint effort which has proved so valuable in industry. Joint effort of this character must be planned by management methods which, in many instances, are beyond the possibilities of the formalized procedures of the educational program.

It is nonconformance to this scholastic, academic, rather than realistically practical, pattern which may offer an explanation for the fact that many who in later years become outstandingly successful in their profession were ranked in the low divisions of their class when in college. Indeed, it is admitted that graduation from college with an excellent scholastic record is not *sine qua non*. Possibly these are the men who, as students, were bold enough to break away from the accepted pattern even at the risk of losing academic caste.

The typical student is immature and meagerly endowed with the subjective traits which characterize the creative mind, those native traits with which he must be endowed by birth if he is to display creative ability in his future work. Only a few may be expected to engage successfully and profitably in creative activities of the type indicated but, in one way or another, most, if not all, will ultimately find a place of usefulness in the vast activities of engineering and technology suitable to their peculiar abilities and qualifications.

There is reason to be disturbed by the possibility that native ingenuity may be submerged and overwhelmed by the formalized processes of the college course. To quote the authors, "whatever ingenuity a man may possess is often so deeply buried under a four-year layer of erudition that it takes years for it to reappear, if it ever does." Herein lies the danger. But are erudition and ingenuity necessarily incompatible? Book learning, if it is worth-while, should serve as

a sort of vicarious experience which, it is believed, will enable the young man who is temperamentally fitted for an engineering career to attain maturity in his ways of thinking and acting more rapidly than by the slow and laborious road of trial and error. These students are not yet stabilized in their mental habits. They are in a state of progression. Their immediate value to industry lies in their promise for the future rather than in their demonstrated attainments.

This is not to say that the colleges should not do everything possible to detect latent creative ability and originality and to encourage and stimulate it. The first essential to this end is for the members of the staff of instruction to be fully conscious of the potentialities. They must be enthusiastic in their support of the common effort of the faculty to develop these qualities in their students. Many educational institutions are making great progress in a conscious effort to encourage and stimulate originality. If this paper serves to influence those in charge of such efforts in our colleges to relate for the benefit of all the specific methods which are being employed to stimulate the development of ingenuity, and if it induces active discussion among engineering educators on this important topic, much value will result.

It takes time and practical experience to make a first-class engineering designer. A few hundred hours in the college shops and drafting rooms can hardly be regarded as the equivalent of many thousand hours of practical shop and drafting-room experience in the realistic atmosphere of industry which an apprentice must serve before he becomes passably competent. Making a few exercise pieces in the college shops or spending three hours per week in the school drafting room, interspersed with many other hours of study and recitation in widely diversified subjects, spreads the ointment pretty thin. The *art* of creative and constructive action is concomitant with actual practice and plenty of it. It is in the practical, pragmatic environment of industry itself that the best results can be obtained and properly evaluated.

The school does accomplish a notably good job if it builds the essential background in the fundamentals of the engineering profession. The aim is to develop a well-rounded man and there is no universal formula by which this may be done. The active, energetic youth can take about so much of formal education. He gets "fed up" with theory, hypothetical problems, and suchlike artificialities of the academic scene. What he wants and needs is the stimulus of participation in the real world of engineering affairs.

COMMENT BY MYRON R. BOWERMAN[8]

The old motto reads, "Necessity is the mother of invention." In the matter of creative ability, is this statement true? Is necessity the mother of invention, or may it be the foster mother only?

I believe we may accept this motto as an axiom. Without necessity we accomplish nothing. As in mechanics, there must be either an outer attraction or a compulsion. Initiative, ingenuity, perseverance are never exhibited unless the worker is attracted or propelled by a force greater than his own inertia. Ambitions for future rewards enable many a young man to go through the training and hardships necessary to win these rewards. Present needs, personal and social, impel sustained effort. Pride in accomplishment and desire for prestige are strong forces directing men's energies toward useful work. Temporary stimulus, however, will not result in great achievement. Real accomplishment must always depend on the formation of good work habits. Our training programs in educational and industrial organizations should take all of these factors into consideration.

Life habits are derived largely from home training and the necessities arising from the family life. Many times schools and colleges are credited with results achieved at an earlier period. With no desire to minimize the credit due to alma mater, may we suggest a corollary to the first statement, namely, "Mother is the necessity for invention," or father.

In many a farm home a boy receives a most thorough foundation for industrial education. He develops skills and abilities at an early age. He learns the rudiments of a dozen trades. Without sufficient equipment, he must contrive repairs. The harvest must go on. When machinery jambs, he must free the wheels, adjust the links, do the work at all odds. Resourcefulness and initiative become part of his life equipment.

Some of our educational developments make the path too easy, remove the mystery and the necessity for search. The course may be so clearly charted that the pupil simply inserts his feet into the tracks ahead. We try to do something for the pupil instead of doing something to him. This may be good when building up for mass production, but may leave us without a product to build.

Industry should apply these laws in the training of its personnel. High-school and college graduates entering an industry should know that their training period is just beginning. The laws of motion should be intelligently applied to their promotion, so that their rate of progress may be directly proportional to the attraction ahead and the effort which they put into their work.

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COMMENT BY ARTHUR C. HARPER[9]

Imagination is fundamental to all creation. Ideas must first be conceived before they can be applied. Society is the force which directs man's material and spiritual ends from birth to death. The individual depends upon society, but society itself is nurtured by the riches in the individual. Without enterprising personalities, thinking and creating independently, human progress is impossible.

The authors isolate this fundamental and advocate correctly that engineering training should be designed and administered, first to select those students who give evidence of having creative ability, and secondly to enhance or develop the particular faculty.

Creative ability is necessary in most types of employment and in fact in most things that go to make up life. For example, a salesman must create a desire on the part of the customer to possess an article. Selection of the salesman is of importance, for you would hardly select a cross-eyed woman to sell millinery. Yet that same woman might have a high degree of creative ability if employed in the back room making the same hat.

Nature does not distribute her favors equally. To one is given strength of body, to another a brilliant mind. Selection, then, is the first step in guidance. The authors place this responsibility mostly on the shoulders of the colleges. I feel that the search should begin in the public schools. The student graduating from our high schools today has little knowledge of *any* job and its requirements. He should be guided or given the opportunity to find out about definite qualifications for different types of work. Many concrete examples should be brought to his attention. Inspection trips to plants in the vicinity should be arranged and he should be given a relatively clear idea of:

(1) The educational qualifications for the job, (2) the personal qualifications, (3) the number of such workers absorbed by industry yearly, (4) the average salary paid to workers, and (5) the living conditions he might expect with such a salary.

The guidance instructor should be trained both practically and theoretically

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for his job, since it is as important as that of the principal.

Selection and guidance should be continued in college. Here such courses as descriptive geometry and mechanics, among others, offer an excellent opportunity to select men having analytical and creative minds. Guidance should aim to recognize whatever is unique, whatever is distinctive, in each boy and girl and develop that as far as it promises to be profitable to do so.

The authors are correct in stating that most of our ingenious designers came up through the shop and drafting rooms, and that most of them cannot use the more advanced methods of analysis. This, of course, does not mean that these men are unlearned. Their knowledge of shop equipment and shop practices together with that which they have learned through their fingers and by observation of the building of successful machines cannot be discounted. Most of the college graduates come to the employer with little or no practical experience. Charles F. Kettering in speaking of cooperative education makes this statement: "One of the difficulties that a young man has, coming out of school, is reorienting himself, and that is why I think the cooperating schools offer something, because in the ordinary school you 'butt-weld' these boys instead of 'lap-weld' them." It is a pretty sudden change. The practical designer is likewise "lap-welded" and he in all likelihood will always be valuable to industry. When a man of this type slides his thumb down along the scale, looks at the measurement there shown, and says, that is big enough, he may be deciding on the diameter of a shaft for a machine but in his mind he is comparing it with other shafts that he has installed under similar circumstances. Call the process empirical design or what you will; the fact still remains that the shaft is almost certain to function properly.

The authors recommend that the colleges allow greater latitude in the selection and furtherance of machine-design course projects. This is being done in some colleges today. In others the design courses are stereotyped and the problems are seldom changed. Certainly, improvement could be made here. However, the recommendation that at least the more promising students be permitted to construct these or other projects of their own in the college shops, would be impossible in most schools. Such an arrangement would tie up many pieces of equipment and would require floor space which, in most cases, could not be spared for this purpose. It further assumes that the student would be capable of operating machine tools with sufficient precision to machine parts that later could be assembled. This would seem to be a doubtful assumption.

The authors raise the old question of the function of the engineering college. Who shall give specialized training? Shall it be industry, the college, or both? Shall the college give a generalized training, or shall it point to certain definite industrial objectives? Time does not permit a discussion of these implied questions.

The experience of the authors has enabled them to present an excellent description of the program being followed by the General Electric Company. The curriculum of the mechanical-design course unquestionably meets the requirements of that company. A discussion of the methods used in selecting candidates and of the operation of the course will add to the value of this excellent paper.

Comment by Paul B. Eaton[10]

The analogy of the function of a creative mechanical designer to that of a mother giving birth to a child is a happy one even though I have a faint suspicion that the authors and I shall never know how truly apt the comparison may be in all its implications. Birth of a being is a biological function—a natural result of desire to create—and the birth of an idea springs from the same source. But just as we have unworthy parents reproducing undesirable children to form a part of our society, so there are immature, uneducated, and even sterile minds conceiving ideas for the more competent to digest.

I assume the authors' definition of a creative mechanical designer connotes one trained in a general way in the fundamentals of natural science, the exact science (mathematics), manufacturing processes, and technological studies, and that they exclude entirely the purely inventive mind of, say, the turn of the century.

I join with the authors in believing that creative flair (ability) is born in a man, and that schools and colleges should attempt to detect this undeveloped ability by giving it proper exercise and encouragement. Many engineering educators have recognized the weakness in the present educational system but there is little one can do about it in a formal way; however, much can be accomplished through an informal approach to the problem of benefiting the mind possessing the unusual gift of creative ability.

As to the discovery of this type of student: Without becoming too didactic, I believe the discovery is relatively simple for the teacher who has considerable contact with his students.

My remarks will apply therefore to institutions of moderate size and not to those schools where students are known only by number and never by name. But even in the latter case, the field for investigation may be narrowed to a relatively few, since only students with at least *some* superior grades need be considered. I say *some* superior grades instead of *all* because this type of student will not be attracted to all of his studies, in fact some will be repugnant. One may also expect to find certain marked physical and personal characteristics exhibited—indifference to personal appearance, abstraction in thought, disinclination for even casual associations, and, generally speaking, an unsocial individual. If the student has hobbies in addition to the foregoing marked characteristics, one may rather safely decide that here is a student worthy of careful consideration.

May I raise a question that I trust is more academic than real? If certain students are given special training (assumedly at the expense of a well-rounded curriculum), how can we in the colleges be assured that industry will give them an opportunity? Are personnel men skilled in detecting the type and is industry as a whole prepared to receive them and carry on where we in the educational field have left off? The General Electric Company, I believe, can answer these questions in the affirmative for they have developed a carefully planned program. But how many other industrial organizations are similarly prepared? Optimum results cannot be attained by subjecting the embryonic creative designer to the program used for training the average college apprentice. A separate mechanism must be employed differentiating itself from other so-called standards at least in the method of personal relations between those administering the program and those pursuing it because of the peculiar temperament of the young designer.

What can the colleges do to aid in this movement?

1 Recognize the need of securing the utmost from this type of man even though it comprises but one to two per cent of our undergraduates.

2 Permit reasonable flexibility by deleting all social studies in a prescribed curriculum to secure as wide and intensified a technological undergraduate program as possible.

3 Extend the use of shop and labora-

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tory equipment and develop a hobby shop where any student may work in his spare time under the guidance of a skilled mechanic.

4 Attempt to form a closer bond between the colleges and personnel representatives from industry by impressing upon industry that such individuals are available and that industry must handle them in a manner commensurate with the mental and physical characteristics of the young mechanical creative designer.

A word of warning to industry may not be amiss: Industry cannot expect something for nothing. It must expect to be compelled to handle these men in an unusual way if optimum and mutually beneficial results to the individual and industry are to be secured. The investment of time and money may be considerable, but the reward to industry and society may be manyfold. Education and industry have the opportunity to meet on a common ground in this worth-while endeavor to get the most from this type of individual at a time when new fields for industry must be developed. We are not discussing an academic matter but one that is vital and therefore real. The General Electric Company is to be highly congratulated in pioneering this undeveloped field

AUTHORS' CLOSURE

The authors are gratified by the generous amount of helpful discussion which their paper has evoked, and wish to thank those who have contributed their comments for the many valuable ideas submitted. Because of space limitations, only those discussion points which take issue with the original paper will be treated here.

Speaking of the difficulty the colleges have in discovering and encouraging creative ability, Prof. Dale states that the teaching techniques of imparting information and aiding understanding are quite distinct from those techniques which would develop the creative mind. But are they necessarily? Cannot the didactic part of the teaching process be limited to a concise presentation of fundamentals, from which point the student may go forward under his own power with as much or as little direction as he requires? To be sure, many may flounder and thereby demonstrate that their feet must be "put in the tracks," as Mr. Bowerman phrases it, to carry the educational process further. But those who are able to rise to the challenge with ability and originality should not be denied the joys of discovery and achievement nor the practice in effective self-education which must be continued throughout life.

As an example, the authors know of a machine-design course in which the term project is the design of a certain well-standardized type of machine. At the beginning, the student is given an extensive outline of the various steps he must follow in order to arrive at an acceptable design. All of the possible pitfalls are underscored and to forestall any unorthodoxy whatever, a picture of one such machine is included. Certainly this is not the "vicarious experience which . . . will enable the young man . . . to attain maturity in his ways of thinking and acting more rapidly than by the slow and laborious road of trial and error." How much better it would be if the student were encouraged to work out an idea of his own, or one given to him in sketchy form, combining his imagination, technical knowledge, and judgment to produce the best engineering solution of which he is capable. Undoubtedly, there will be oversights and errors, but these will be indelibly impressed on his mind, when pointed out by a capable and respected teacher. In contrast to vicarious experience, this provides real but accelerated experience. Moreover, it tends to bring out the qualities of originality which otherwise might escape unnoticed and unencouraged.

The authors are well aware of the difficulty of finding adequate shop equipment for the use of specially gifted students, as pointed out by Prof. Harper. Whether the articles so built are products worthy of a first-class craftsman is of secondary importance; as much is learned through mistakes and misfits as through unimpeded success. Education through the hands is achieved in any event.

The original paper may not have given a sufficiently definite description of the methods used by the General Electric Company in selecting men for its mechanical-design course. In this connection, the personnel records of the student engineers on the first-year test course are scrutinized for evidences of interest and ability in mechanical matters, excellence in certain college subjects, and resourcefulness. The more promising of these men are then interviewed carefully by the senior designers who comprise the advisory committee. Final selections are made on the basis of their reactions, taking into account pertinent information gleaned from the individual's performance while employed by the company. Entrance to the mechanical design course is not limited, however, to those on the test course; a determined effort is made to find talent wherever it exists, whether in the drafting room, in the shop, or in the engineering office. If this requires modification of the training program to meet an individual need, the promise of results is deemed worth the extra effort.

A. R. STEVENSON, JR.[11]
J. E. RYAN.[12]

Future of Power Use in the Pacific Northwest

COMMENT BY R. F. BESSEY[13]

The subject matter of this paper,[14] i.e., the future of power use in the Pacific Northwest, is inextricably linked with that of the region itself. The growth of power use is dependent in considerable part upon general regional development and, reciprocally, the use of the great power resource is a very important factor in the regional growth.

The growth of this region, in such basic areas as population, land use, and industry, may be expected to proceed at a rate greater than that for the nation as a whole. Favorable factors include migration trends, available land and other resources. Power is a strongly impelling factor in several ways. Hydroelectric energy is an outstanding resource of the region. Its development in multiple-purpose projects is an aid in development of navigation and commerce, and of irrigation and land and, perhaps most significantly, in filling the gap in regional manufacturing mentioned by the author.

The Pacific Northwest Regional Planning Commission has been considering the resources and the future of the region for the last several years. In 1935, with special reference to organization for the planning, construction, and operation of federal public works;[15] currently, in relation to migration and basic economic opportunity on land and in industry.[16]

In its 1935 study, the commission saw saturation of the power market as far from an early prospect. The members thought that the factors which had

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[13] Consultant, Pacific Northwest Regional Planning Commission, and National Resources Planning Board, Portland, Ore.

[14] "The Future of Power Use in the Pacific Northwest," by H. V. Carpenter, MECHANICAL ENGINEERING, vol. 62, Sept., 1940, pp. 663–664 and 672.

[15] "Regional Planning, Part I—Pacific Northwest," Columbia Basin Report, Pacific Northwest Regional Planning Commission, National Resources Committee, 1936.

[16] "Migration and the Development of Economic Opportunity in the Pacific Northwest," Pacific Northwest Regional Planning Commission, 1939.

brought about great increases in power use would still be operative: Increases in population, in buying power, in standards of living, in per capita use, in areas served, in proportion of homes served, in uses in homes, in use of home and farm appliances, in uses in agriculture and forestry; decreases in cost of equipment and installation, in cost of power, also in use of mechanical power; decentralization of industries, increase in per capita manufacturing activity and in self-supporting capacity of region; technical advances in electrical utilities and industries; increased volume and raised standards of lighting (indoor and outdoor, commercial, industrial, public); and, possibly, increased future exportation of energy.

The effect of these rather indeterminate factors has commonly been reduced to assumptions of continuing compounding rates of increase. But, since these rates cannot go on indefinitely (there must be a ceiling and an "ogee" form for the curve), it is desirable to look carefully at some of the fundamental factors in an effort to gage potentialities, ceilings, and trends. In the brief space allotted to this discussion, we can consider some of the essentials in three fundamental fields: (1) land and agriculture, (2) industry, and (3) population—all with reference to the next three decades, let us say.

There is a rather definite ceiling in land development; perhaps 7,000,000 or 8,000,000 acres or, roughly, 50 per cent at most can be added to the crop lands of the region. Undoubtedly, because of extension of irrigation and agriculture in metropolitan districts, this would involve more than 50 per cent increase in the number of farms. Rural electrification has jumped about 60 per cent in the last 6 years; one half the farms of the region are now electrified, so this ceiling is another 50 per cent but perhaps the practical ceiling is considerably less. More important than these factors, however, are those of greater use of electrical energy on farms and in agriculutre. Electric service to farms in the United States has about quadrupled in the last 10 years. But, in the state nearest the ceiling, California, use per farm is still about 5 times that in most other states, including those of the Pacific Northwest.

A special condition in the Pacific Northwest is potential need of large quantities of power in irrigation pumping, not only on great projects like the Columbia Basin, but in numerous areas both east and west of the Cascades. It seems probable that the use of electric energy in this whole field will increase several fold in the next 30 years, but it should be borne in mind that present usage therein accounts for only a small fraction of total consumption.

In industry, the most important field of power use (from an economic standpoint), trends are difficult to determine. We might expect, roughly, a 60 per cent increase in regional industrial output on the basis of past long-term trends. This percentage is likely to be increased materially if the region takes up, as it should, some of the aforementioned slack in its manufacturing activity. Many new industrial increments, especially electrometallurgical and electrochemical industries, big consumers of energy, seem certain to become established in the region as a result of the large volumes of firm, low-cost power available on grid transmission lines. These will cause a sharp rise from past trend lines. Also, much more significant than past trends in industrial production are trends in power use in relation to output or numbers of workers. The power available to the industrial worker is quite likely to increase more than twofold during the next 30 years. The total effect is likely to be a three- or fourfold increase in industrial use of power during the period in question.

With respect to population, it is somewhat easier to visualize a ceiling. The national population is expected to reach a ceiling in about 40 years. But population growth in the Pacific Northwest has resulted, and will result, more from migration than from natural increase. Present trends of movement toward the region may be expected to continue (because of various factors: long-term movements, land and other resources, economic opportunity differentials, etc.) with a population increase of perhaps 50 per cent in the next generation. While this may not be a ceiling, it may not be so far from it unless there is a disproportionate increase in the industry and commerce of the West. As noted, this population growth will have effects upon growth in other fields: industry, agriculture, land use, etc. It will not in itself account for the compounding increases in power use. Continued acceleration of power uses by the individual farmer or worker, by the individual home or farm, and by agriculture, industry, commerce, and the public will have an effect several times greater than the increase in population. The ceilings for increased usage are not likely to be closely approached within the next few decades. The combined effect seems likely to be a threefold increase in power demand. Incidentally, with city-limit populations reaching saturation, and with transmission networks available, population trends of large areas are better guides to power use than those of cities.

In conclusion, rough analysis on the foregoing basis seems to justify the assumption that growth of power demand in the Pacific Northwest during the next few decades will be considerably above the lower limit ($4^1/_2$ per cent, compounded annually) plotted by the author and high enough to demonstrate the soundness of the present regional power plant and transmission-grid program. The writer believes that various technical studies (such as those of the Bonneville Power Administration, as well as those of Dean Carpenter and of Dean Magnussen at the University of Washington) will do likewise. Developing demands of defense industries may call for an immediate acceleration of part of that program.

Finally, in view of the wide ground covered so sketchily, it is desirable to add one or two of the more obviously needed qualifications: Judgments are predicated, of course, on continued national growth in industry, technology, wealth, and living standards. Further, it is assumed that, in order to get optimum results in power use and general regional advancement, there will be ample provisions for effective development, administration, and correlation of facilities for the production and transmission of energy; for research, experimentation, and demonstration in the use of power and other resources; and for planning, design, and action in land reclamation and utilization, industrial location, and transportation-system improvement.

COMMENT BY W. A. DITTMER[17]

Since the marketing of power to be generated at Grand Coulee Dam has recently, by executive order, been assigned to the Bonneville Power Administration, we are of course vitally interested in the subject of this paper. We feel that Bonneville and Grand Coulee for a number of years will furnish the principal additional power supply for Oregon and Washington. Very little capacity has been installed by private utilities in the last 5 years, and there seems to be no reason for anticipating any further installations in the immediate future because the government is developing large power projects along the Columbia River.

The author is optimistic regarding the

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growth possibilities in the Northwest, and it may be said that we agree with his optimistic view, only much more so. He seems inclined to the view that the power to be available at Bonneville and Grand Coulee will be marketed only over an extended period of time. It is our view that the total amount of power to be available at the two dams will be disposed of within a period of 10 years. We at Bonneville have been undertaking some rather extensive studies of the capability of the various generating plants in the Northwest, and of the growth of load in this territory. The summation of the maximum demands in the states of Washington and Oregon for the year 1939, as given in the Federal Power Commission reports, is 1,010,000 kw. It is estimated that the maximum demand, in the fall of 1940, would be 1,160,000 or 1,170,000 kw. That represents an increase of about 160,000 kw in a single year including 60,000 or 70,000 kw of high-load-factor industries taking Bonneville power direct.

The total installed capacity in the two states, including two Bonneville units of 43,200 kw each, is 1,414,667. These figures are somewhat higher than those shown by the author. The difference is due probably to the fact that we included not only generating capacity owned and operated by public utilities and public bodies, but also the capacity of generating plants owned by nonutility manufacturing concerns, in so far as such capacity was actually used for the generation of electricity distributed to the public.

With a total of only 1,415,000 kw of installed capacity (at name-plate rating) in Washington and Oregon, there will be insufficient reserves in the territory to provide adequately for the load anticipated during the fall months. This is due to the fact that the bulk of the capacity is hydro and many of the plants do not have sufficient water during critical stream-flow periods to deliver full rated capacity. Many areas in the two states are definitely deficient in capacity at the present time. This is true of the Portland area, Astoria, the Willamette Valley served by Mountain States Power Company, the Grays Harbor territory, and others. Eastern Washington is drawing a part of its supply from Montana which itself has very little if any surplus.

We assume with the author that the increase in ordinary load during the period immediately ahead will probably lie somewhere between the $4^1/_2$ per cent of the last decade and the 10 per cent of the decade 1920–1929. If we assume a growth of $7^1/_2$ per cent per year, the load would just about double in a 10-year period. That would take up approximately 1,200,000 kw out of a total of perhaps 1,500,000 kw of firm power which will be available from Bonneville and Grand Coulee, leaving only 300,000 kw to make up the current deficiency in reserves and allow for high-load-factor industries (electrometallurgical and electrochemical) which are just beginning to come into this area. In no other part of the United States are the large blocks of low-cost power required by such industries available.

Summing up: The total load in Oregon and Washington during the fall of 1940 will approach 1,200,000 kw. Present installed capacity is not sufficient to take care of this load with proper reserves. Assuming a growth of $7^1/_2$ per cent, and only a moderate amount of new high-load-factor industrial demand, the total installed capacity of Bonneville and Grand Coulee when completed may reasonably be expected to be used up within a 10-year period.

COMMENT BY E. R. HOFFMAN[18]

The writer wishes to comment on various statements in this paper as follows:

(*a*) On the statement that "only three or four plants in the area are able to store enough water to maintain full rated operation through the months of August, September, and October."

It is already evident, from the 360-month record now available for the Skagit River, that the critical low-water period is more likely to be one having a duration of 7 months than of only 1 or 2. Index numbers for Skagit average monthly flow, using September as a basis, are as follows:

Month	Index (30-year avg)
August	155
September	100
October	103
November	118
December	115
January	98
February	90
March	92

These are *average*-flow figures. Of *minimum*-flow months, February is again the lowest, one February having a flow of only $24^1/_2$ on the basis of 100 for the average September.

(*b*) On the statement that "220,000,000 kwhr of storage is available, etc."

Up to the present time, far too little attention has been given to the fact that such storage estimates are based on two assumptions. One of these is that the load dispatcher can tell when the low season will end. The other is that the use of storage water will increase the kilowatthour output of the power plant. This last has long been accepted as obvious; but experience is already proving that it is often untrue. This is because the power gained by increase in amount of water used can be more than canceled by the power lost by reason of decreased head. Thus, if a reservoir, serving a power plant, is drawn down 100 ft, reducing the power head from 250 ft to 150 ft, the average head lost is 50 ft, and the average power output is decreased by at least 0.2. In this case, it becomes evident that storage use must increase the natural flow by 25 per cent or, for example, from 400 sec-ft average to 500 sec-ft average, before there can be any gain at all in the kilowatthours of power-plant output.

The future implications of this condition of affairs are somewhat astonishing. Suppose, for example, that the phrase "use of storage" should, when hydrodevelopment has reached its ultimate value, be supplanted by the phrase "sacrifice of power head;" and, further, that the practice itself should finally be excusable only when there is no steam auxiliary to carry the load.

(*c*) On the use of the expression "per cent compounded" to illustrate growth of power demand.

This method, although quite common, is certainly not one of the best, as can easily be proved by the following example taken from the Federal Power Commission's Interim Power Report released in 1935. By rearranging certain of the data given on installed power-plant capacities of the Pacific Northwest and of the United States, and converting them to index numbers, based on 100 for the end of the year 1934, we arrive at the following very simple setup:

At end of	Pacific Northwest	United States
1905	2	1
1925	59	59
1934	100	100

The coincidence of the figures, for 1925 and 1934, makes it obvious that future prediction, in 1925 for 1934, would inevitably have resulted in a 100 per cent error, if based on the "per cent compounded" increase from index 2 for Pacific Northwest, and index 1 for the United States.

A far better method is to assume, from past experience, the number of years in which the present amount of installed capacity will be doubled. For the three

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or four states included under the name Pacific Northwest, this figure may prove to be not very far from 14 years, taken from any recent or proximate year as a starting point.

In fact, a little reflection may lead to the conclusion that this interval of "years to double present installed capacity" is one of the most important targets for our future estimate.

AUTHOR'S CLOSURE

It has been gratifying to find that the two government agencies most directly interested in the future of the Pacific Northwest, represented by Major Bessey and Mr. Dittmar, are fully as optimistic on the outlook as is the author. Naturally, the effect of defense manufacturing is already (January, 1941) increasing our optimism. Contracts for power from Bonneville are being dated according to the time new units can be made ready; and it is quite likely to be the same at Grand Coulee, where the first of three 108,000-kva units is due to be in operation by August, 1941. The table on which were based the totals for hydro power given in the paper is too detailed and extensive to be given here. Some additional totals deduced from it follow.

Hydro power available at present in the Columbia River network area, from Flathead Lake, Montana, west, including northern Oregon and excluding Bonneville and Canadian plants: Installed capacity, 1,036,000 kw; maximum from average September flow, no storage, 551,000 kw (lowest recorded September flow about 40 per cent less); total possible kwhr in storage reservoirs, about 800,000,000; available in average September, reservoirs full, 70 per cent load factor 980,000 kw.

The addition of ten machines (ultimate) at Bonneville and 18 machines at Grand Coulee (ultimate) will add 515,000 kw plus 1,890,000 kw less 500,000 kw for irrigation pumping at Grand Coulee and will change the picture completely since low water on the Columbia comes in January and February. This low water is to be offset however by the use of the irrigation power not needed in winter. This together with the enormous storage above Grand Coulee and in the upper Columbia lakes seems to assure full power continuously from both federal plants except that high water in June and July may limit the Bonneville output to some extent.

Mr. Hoffman's point regarding the impossibility of using stored water with 100 per cent effectiveness is, of course, well taken. In the totals just given, it has been assumed that the operating staff has been wise or fortunate in predicting the time and rate at which storage should be drawn upon. As to the reduced energy available from storage due to reduction of head as the reservoir is drawn down, it would seem that Mr. Hoffman has been somewhat pessimistic, since a great deal more than 25 per cent of the stored water is in the upper 25 per cent of any reservoir. It is freely admitted that estimates of available kilowatthours from storage must be accepted with a suitable degree of tolerance, since the unpredictable water supply must be used according to the judgment and experience of the engineers responsible. It must not be overlooked that the improvements in interconnections, which are resulting from the 230-kw network being built by the Bonneville Administration and the new tie between the Idaho-Utah systems and the Montana Power Company, will greatly reduce the dangers which result from the overoptimistic use of stored kilowatts.

H. V. CARPENTER.[19]

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A.S.M.E. BOILER CODE

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possibly any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-299 (*b*). Revise to read as follows:

(*b*) The thickness of all fittings or valve bodies subject to pressure shall be not less than that required by the American Standard for the corresponding maximum allowable working pressure, temperature, and the material used, EXCEPT THAT IN ORDER TO PROVIDE EQUAL THICKNESSES FOR WELDING, THE CYLINDRICAL ENDS OF CAST STEEL WELDING END VALVES AND FITTINGS MAY BE PROPORTIONED WITH A QUALITY FACTOR OF 100 PER CENT PROVIDED THESE AREAS ARE FINISH MACHINED BOTH INSIDE AND OUTSIDE AND CAREFULLY INSPECTED. IN NO CASE, HOWEVER, SHALL THE THICKNESS OF THE ENDS BE LESS THAN THAT OF THE ADJOINING PIPE. THE MACHINED ENDS SHALL BE TAPERED ON A 1:4 MAXIMUM SLOPE FOR A DISTANCE MEASURED FROM THE CENTER OF THE WELD OF APPROXIMATELY $1^1/_2$ TIMES THE PIPE WALL THICKNESS. THE REMAINING TAPERED SECTION MAY BE CAST OR MACHINED ON A 45 DEG ANGLE.

THE CASTING QUALITY FACTORS GIVEN IN TABLE P-7 DO NOT APPLY TO AMERICAN STANDARD CAST STEEL FITTINGS WHOSE DIMENSIONS AND RATINGS ARE INCORPORATED IN THE CODE (TABLES A-5, A-6, A-9, AND A-12).

PAR. U-1 (*a*). Revise definition of "*P*" to read: *P* = MAXIMUM ALLOWABLE WORKING pressure, lb per sq in.

PAR. U-2. Insert the following between the first and second sections:

Safety valves shall be connected to a vessel in the vapor space above any contained liquid. Additional liquid relief valves may be connected below the normal liquid level if a vessel is to contain liquid, and such relief valves may be set at higher than the maximum allowable working pressure. (See Par. U-19.)

PAR. U-4. Revise to read as follows:

The pressure at which a safety VALVE [device] is set to operate shall not be in excess of the maximum allowable WORKING pressure stamped on the vessel.

PAR. U-6 (*a*). In fifth line, insert "working ahead of "pressure."

PAR. U-12. Transfer (*c*) to (*a*), revising (*a*) to read as follows:

(*a*) All materials used in the construction [of the important parts] of unfired pressure vessels for which specifications are given in Section II of the Code shall conform to such requirements, EXCEPT THAT CAST, FORGED, OR ROLLED PARTS OF SMALL SIZE FOR WHICH IT IS DIFFICULT OR IMPOSSIBLE TO OBTAIN IDENTIFIED MATERIAL, OR WHICH MAY BE STOCKED AND FOR WHICH MILL TEST REPORTS OR CERTIFICATES CANNOT BE ECONOMICALLY OBTAINED AND ARE

NOT CUSTOMARILY FURNISHED, MAY BE USED FOR RELATIVELY UNIMPORTANT PARTS OR PARTS STRESSED TO NOT MORE THAN 50 PER CENT OF THE STRESSES PERMITTED BY THE CODE, WHICH DO NOT APPRECIABLY AFFECT THE SAFETY OF THE VESSEL, PROVIDED THEY ARE SUITABLE FOR THE PURPOSE INTENDED AND MEET THE APPROVAL OF THE INSPECTOR.

PAR. U-13 (g). Add the following:

Class	Maximum tension	Maximum bending	Maximum compression
25	2500	3750	5000
35	3500	5250	7000

PAR. U-19. Revise first sentence to read as follows:

The maximum allowable working pressure FOR A VESSEL IS THE MAXIMUM PRESSURE AT THE TOP OF THE VESSEL IN ITS NORMAL OPERATING POSITION. IT is determined by employing the factors of safety, stresses, and dimensions designated in these rules.

Transfer Par. U-20 (d) as third section of Par. U-19. Add the following as the fourth section:

The maximum allowable working pressure for the vessel as a whole is the least of the maximum allowable working pressures determined by computations for the various parts.

PAR. U-20 (a). In the second line, insert "cylindrical" ahead of "shell;" in the third line, insert "relative to the loads upon it" ahead of "computed." Add the following:

The maximum allowable working pressure for shells other than cylindrical, and for heads and other parts, shall be determined in a similar manner using the formulas appropriate for the parts, as elsewhere given in this Code.

Material Specifications: The following specifications are to be revised to conform with the A.S.T.M. Specifications indicated:

A.S.M.E. Specifications	A.S.T.M. Specifications
S-17	A83-40
S-18	A53-40
S-22	B13-40
S-24	B43 -40T
S-32	A178-40
S-33	A157-40
S-34	A158-40T
S-35	A182-40
S-36	B96 -40T
S-37	B98 -40
S-38	B25 -40T
S-39	B126-40T
S-40	A192-40
S-41	B61 -40
S-45	A206-40T
S-47	B111-40T
S-48	A209-40T
S-49	A210-40
S-51	A194-40
S-56	A216-40T
S-57	A217-40T

A.S.T.M. Specifications A225-39T for Manganese-Vanadium Steel Plates for Boilers and Other Pressure Vessels to be incorporated in Section II of the Code as Specification S-60.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Mastering Momentum

MASTERING MOMENTUM. By Lewis K. Sillcox, D.Sc. A Discussion of Modern Transport Trends and Their Influence Upon the Equipment of Modern Railways. Simmons-Boardman Publishing Corporation, New York, N. Y., 1941. Cloth, 6 × 9 in., 274 pp., illus., $2.50.

REVIEWED BY S. W. DUDLEY[1]

IN "Mastering Momentum" the author, L. K. Sillcox, first vice-president of the New York Air Brake Company, at Watertown, N. Y., has assembled in a convenient volume the material discussed in six papers privately published and presented by him before the students of the Massachusetts Institute of Technology from 1936 to 1941. Dr. Sillcox is well qualified by his scientific and technical training and by his experience in manufacturing and railroading to review authoritatively the trends in modern transportation and point out their influence upon the equipment of American railways.

Educated in the École Polytechnique, Brussels, Belgium, he was successively an apprentice on the New York Central System, shop supervisor in a Midwest manufacturing plant, and shop engineer for the Canadian Car and Foundry Company, Montreal, before he entered upon his first railroad executive job as mechanical engineer for the Canadian Northern Railway System in Toronto. From this position he went to the Illinois Central System and then was called to assume heavy responsibilities as general superintendent of motive power for the Chicago, Milwaukee & St. Paul Railway at the time of its main-line electrification. Since 1927 he has been first vice-president of the New York Air Brake Company, Watertown, N. Y.

During this latter period he has continued his close association with railroad officers and railway operating and equipment problems throughout the country. He has exerted an active leadership in technical committees and commissions of the government (he was chairman of the Mechanical Advisory Committee under the federal coordinator of transportation, 1934–1936), of The American Society of Mechanical Engineers, of the Mechanical Division, American Association of Railroads, and numerous other societies.

The results of his experience with the major problems of transportation as a powerful servant of present-day civilization have been presented to advanced students in transportation, not only at Massachusetts Institute of Technology, but also at Harvard, Princeton, and Yale.

A detailed analysis of the factors constituting "The Mechanics of Train Operation and Train Braking" constitutes the first third of the present volume. Sufficient theoretical analysis is presented to establish a rational basis for the discussion of the energy transformations encountered in the starting, accelerating, retarding, and stopping of passenger and freight trains. The interrelationships of the contributing functional elements, viz., the locomotive, the cars, the brakes, and the signals, are discussed briefly before entering upon a review of some of the significant stages in the development of power braking apparatus for railways. Each stage in this development has been marked by public trials or demonstrations, commencing with the classic Galton-Westinghouse trials, 1878-1879, on the London, Brighton & South Coast Railway, England, reported by Captain Douglas Galton to the British Institution of Mechanical Engineers in three epoch-making papers, and ending with the "Pioneer" *Zephyr* high-speed train brake trials of 1934.

The long-familiar braking variables—wheel and rail adhesion and the frictional resistance offered by the brake shoe—are

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discussed at length in the light of the knowledge gained by more refined instruments and methods of observation and analysis devised to meet the new and extreme conditions of modern high-speed trains. There follows a brief consideration of the types of brake equipment developed to meet the increasing demands of long and heavy freight trains, running at what were formerly average passenger-train speeds and those of the modern high-speed passenger trains, including the lightweight "streamliners." The general operating characteristics of the new forms of air-brake mechanisms are described with discussion of their relationship to modern train-operating problems.

Procedures to be observed in computing train-stop distances are explained at length. It might be noted at this point that the author's warning to the uninitiated to be on guard against offhand assumptions of critical values subject to considerable and sometimes unsuspected variability cannot be overemphasized.

Detailed consideration of major factors other than the braking apparatus and its accessories follow, viz., the car wheel, the car axle, locomotive and truck design, rail reactions and riding qualities, and the draft gear.

In each instance causes for failures of several types are mentioned and remedial measures explained, including interesting applications of modern methods of stress analysis. Disk brakes and rotor brakes, by which the wheel treads are relieved of the action of frictional braking forces, are mentioned among other recent and promising developments.

Photoelastic analysis is described as a tool of great power and effectiveness in the determination of undesirable stress concentrations in car axles. Resultant improvements in design data and procedures are presented.

The author discusses authoritatively the effect upon truck design of service requirements, roadbed, car weight, suspension characteristics, and other pertinent details of construction and road operation.

The section on the draft gear traces the origin and development of this device from a consideration of the relative movements of the several units comprising a freight or a passenger train to the effect of the various train service variables which combine serially or simultaneously to cause "slack action" and the resultant shocks between adjacent vehicles in the train. How the draft gear performs its function in the harmless absorption of the energy thus released, its characteristics and its limitations, and a discussion of the "cushion underframe" representing the latest approach to the train slack control problem, closes this chapter.

Drawings of typical pneumatic-brake equipments with corresponding brake-pipe, brake-cylinder, and reservoir pressure curves are grouped together for ready comparison in the Appendix. There is a convenient index.

Pressure Vessels and Tanks

MANUAL FOR THE DESIGN OF FERROUS AND NONFERROUS PRESSURE VESSELS AND TANKS. By Karl Siemon, Metuchen, N. J. Published by the author; printed by the offset process by Edwards Brothers, Inc., Lithoprinters, Ann Arbor, Mich., 1940. Cloth, $5^1/_2 \times 8^1/_2$ in., 280 pp., $3.

REVIEWED BY C. W. OBERT[2]

THIS volume has been prepared by the author as a guide for the design of pressure vessels to meet the exacting requirements of modern operating conditions in the process and chemical industries. The purpose of this Manual is to render available to the reader a deeper and more comprehensive understanding of the available construction materials to withstand corrosion at high temperatures as well as of fabricating processes that will serve to meet the peculiar and exacting needs of present-day practices in this field.

The author explains that the problems encountered in designing pressure-vessel equipment to meet the exacting requirements of modern high-pressure and high-temperature processing conditions have led to many more or less complete test and research investigations. Unfortunately, however, the reports of such investigations are scattered throughout the periodicals and technical publications so that they are not readily available to the average reader. He has undertaken, therefore, to bring into convenient form a complete statement of the essential physical properties of the different materials available for pressure-vessel construction and adequate analyses of pressure-vessel formulas and computations. It is his hope that this volume will afford the designer better opportunities to take advantage of what has been learned about the distribution of stresses in pressure containers and the possibilities of producing constructions that are unquestionably safe yet more economical.

The Manual is divided into three parts, the first of which is devoted to the materials of construction, the second to design considerations, and the third, to an appendix which contains much useful design data in tabular form. Part 1 opens with an introductory statement that deals with the theory of corrosion as now appears to be generally accepted by various authorities. A discussion is included of the electrochemical series and references are made to current corrosion data and tests, together with a brief bibliography thereon. Following this statement are to be found analyses and tabulations of the physical properties of the materials covered in part 1 which are so prepared as to concentrate on the data that are most useful to the designer. Special attention is given to the properties that assist in resisting the effects of high temperatures and corrosion. The materials considered are as follows: Iron and steel, steel alloys, copper and its alloys, aluminum and its alloys, and nickel and its alloys.

Part 2 on design embraces 178 pages of text which are devoted in part to design methods and procedures, and the remainder to specialized information concerning the treatment of the various nonferrous materials in actual designs and constructions. Considerable space is devoted in the design chapters to calculation formulas for both internal-pressure and external-pressure conditions. The former devotes a liberal amount of space to comparisons of the formulas available for the design of thick cylinders, such as Barlow's, Lamé's, Clavarino's, Bach's, and Birnie's. For vessels subject to external pressure there are several data references to formulas such as von Mises' and Southwell's, but preference is shown for the A.S.M.E. Unfired Pressure Vessel Code rules which appear in the form of charts based on experimental data. A useful feature of these charts in the Manual is that they have been worked out by the author to cover, in addition to plain carbon steel, such materials as stainless steel, monel metal, and nickel.

Part 2 devotes considerable space to presentation and discussion of computations for head thicknesses, reinforcement of openings, flange design, and the various forms of joints such as riveted and fusion-welded joints. It also contains chapters devoted to the shell stresses that result from both dead loads and wind loads and to the design of supporting legs, columns, and skirts.

The treatment of pressure-vessel details when nonferrous materials are used occupies a large part of the design section and much valuable information is given concerning the special features that must be considered in the design and fabrication

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of these materials, particularly when fusion welding is employed. Due consideration is given to the effect that the varying strengths of such materials have on design and fabricating conditions. For vessels fabricated with clad materials, consideration is given to methods used to insure continuity of the cladding, as well as to the strength of the steel base material.

Throughout the Manual the author has paid close attention to the various Codes that govern the construction of pressure vessels such as the A.S.M.E. Unfired Pressure Vessel Code, the API-ASME Pressure Vessel Code, and the various governmental codes and regulations. He has quoted liberally from the two former codes, for which credit is freely given, and he has supplemented these data references by tabulations of working stresses of the various materials and the allowable working pressures (internal) for vessels made of different materials and of different forms and sizes. The data section in the appendix contains useful information concerning surfaces and volumes of shells, dished heads, and other parts, and gives an extensive list of templates for drilling pipe flanges for the different sizes and pressure ratings of piping.

Books Received in Library

ADKI Konstruktive Lagerfragen, Richtlinien und Beispiele für die Konstruktion der Gleitlager unter Verwendung der Austauschwerkstoffe. Second enlarged edition, im Auftrage der Arbeitsgemeinschaft deutscher Konstruktionsingenieure (ADKI) des V.D.I., by A. Erkens. V.D.I. Verlag, Berlin, Germany, 1940. Paper, 8 × 12 in., 58 pp., diagrams, charts, tables, 10 rm; to members, 9 rm. Plain bearings are briefly described, and lubrication fundamentals are given, with emphasis on the economical use of the proper lubricant for satisfactory operation. The many types of materials which may be used for bearing surfaces are described, and tested constructions are given for bearings as used in various fields.

Aircraft Propeller, Principles, Maintenance, and Servicing. By R. Markey. Pitman Publishing Corporation, New York, N. Y., 1940. Cloth, 5 × 8½ in., 155 pp., illus., diagrams, charts, tables, $1.50. This text has been written to explain the workings of the aircraft propeller to student pilots, mechanics, and laymen. Elementary aerodynamics and the construction and maintenance of propellers are dealt with, and separate chapters are devoted to descriptions of certain types of constant-speed and variable-pitch propellers. There is a list of definitions.

Airplane and Its Engine. By C. H. Chatfield, C. F. Taylor, and S. Ober. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 5½ × 8½ in., 414 pp., illus., diagrams, charts, tables, $3. This book is intended "for the reader who desires a sound knowledge of the basic principles and a broad view of the present development of the airplane and its power plant, without giving to the subject the intensive study which is essential for the designing engineer or the expert mechanic." The new edition has been carefully revised to cover recent developments in all lines.

Annual Reviews of Petroleum Technology, vol. 5, 1939, by F. H. Garner. Institute of Petroleum, The University of Birmingham, Edgbaston, Birmingham 15, England, 1940. Cloth, 6 × 9½ in., 457 pp., illus., diagrams, charts, tables, 11s. Reviews by experts of developments during 1939 are contained in this annual compilation covering the whole range of petroleum technology: geology, geophysics, drilling and production, transportation and storage, refining operations, gasoline and oil engines, lubrication, analysis and testing, etc. A new chapter on addition agents is included in this volume. In addition to chapter references there is a general review of petroleum literature in 1939, and the last chapter furnishes production and commercial statistics.

A.S.T.M. Viscosity Index Tables, 31 pp., $0.50. A.S.T.M. Conversion Tables for Kinematic and Saybolt Universal Viscosities, 10 pp., $0.25. American Society for Testing Materials, Philadelphia, Pa. Paper, 6 × 9 in., tables. The viscosity tables, which are based on the tentative method for calculating the viscosity index, provide a tabulation of the index, calculated from basic Saybolt universal viscosity, against Saybolt at 100 sec under Saybolt values at 210 F for 40 to 161 sec. The conversion tables, which are based on the standard method for the conversion of kinematic viscosity to Saybolt Universal viscosity, provide a quick conversion. The tables range from 2.00 to 330.0 centistokes by increments of 0.01, 0.02, 0.10, and 0.20, depending on the range. The two tables are particularly of interest in the field of petroleum products and lubricants.

ATM (Archiv für technisches Messen) Lfg. 111, 112, 113, Sept., Oct., Nov., 1940. R. Oldenbourg, Munich and Berlin, Germany. Paper, 8½ × 12 in., pp. T97–119, F3–5, illus., diagrams, charts, tables, 1.50 rm each. Three numbers of a monthly publication containing classified articles upon various types of apparatus and methods for technical measurements. Certain numbers also contain descriptions of specific instruments manufactured by German companies.

Airplane Metal Work. Vol. 2: Airplane Sheet Metal Shop Practice. By A. M. Robson. D. Van Nostrand Co., New York, N. Y., 1940. Paper, 7 × 10 in., 109 pp., illus., blueprints, tables, $1.25. This book is intended for mechanics actively engaged in the aircraft industry and for prospective mechanics in training. Following a general discussion of work habits and conduct, the author presents practical information about specific job operations and shop practices, including questions and answers. There is also a full list of tool and miscellaneous equipment and other supplies for the airplane sheet-metal shop.

Axial Adjustment of Deep-Well Turbine Pumps. (University of California Publications in Engineering, vol. 4, no. 2, pp. 19–26.) By M. P. O'Brien and R. G. Folsom. University of California Press, Berkeley and Los Angeles, Calif., 1940. Paper, 11 × 18 in., 25 pp., illus., diagrams, charts, tables, 25 cents. The effect of axial adjustment on deep-well turbine pumps is considered to depend upon the impeller design. Results of experimental investigations are presented showing the effect and reactions with both semiopen and closed impellers.

Bildwort Deutsch, Technische Sprachhefte 4: Chemische Technik, Verfahrenstechnik. V.D.I. Verlag, Berlin, Germany, 1940. Paper, 6 × 8½ in., 32 pp., illus., diagrams, 1.50 rm. This series of pamphlets is intended for non-German engineers who wish to increase their ability to read German. Each consists of a concise account of some branch of engineering illustrated by many drawings in which the name of all important elements is clearly marked, thus providing a pictorial dictionary. The present pamphlet deals with chemical engineering.

Design of High-Pressure Plant and the Properties of Fluids at High Pressures. By D. M. Newitt. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1940. Cloth, 6 × 10 in., 491 pp., illus., diagrams, charts, tables, $10. The first part of this book is devoted to the kinds and properties of materials used in the construction of high-pressure plant and equipment, the calculation of the stresses and strains which must be dealt with, practical design data, and the measurement of high pressures. In part 2 the pressure-volume-temperature relationships of gases and liquids, the equation-of-state problem, and the influence of pressure upon such properties as viscosity, solubility, and refractivity are discussed. Details of experimental methods and procedure are given where necessary, and numerous illustrations and tables of data are included in the text and in appendixes.

Deutsche Kraftfahrtforschung, Heft 45. Leistungsbedarf zur Kühlung des Fahrzeugmotors und seine Verminderung, by H. Schmitt. V.D.I. Verlag, Berlin, Germany, 1940. Paper, 8½ × 12 in., 16 pp., illus., diagrams, charts, tables, 1.90 rm. This report gives the results of investigations of the power required to cool automobile engines and of the possibilities of reducing it. Particular attention is given to the influence of the cooling system upon the air resistance of the automobile and to ascertaining the best method of supplying and removing the air for cooling.

Development of Mathematics. By E. T. Bell. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × 9½ in., 583 pp., $4.50. The author presents a broad account of the part played by mathematics in the evolution of civilization, describing clearly the main principles, methods, and theories of mathematics that have survived, from about 4000 B.C. to 1940. Besides outlining the development of the leading ideas, the book gives the student a well-rounded understanding of the story by explaining the mathematics involved. Details of antiquarian interest are subordinated to a fuller exposition of things still alive in mathematics than is customary in histories.

Displacement, Velocity, and Acceleration Factors for Reciprocating Motion. By L. B. Smith. P.O. Box 317, Hampton, Va., 1940. Paper, 6 × 9 in., 17 pp., diagrams, tables, $0.40 (3 copies, $1). The tables presented in this pamphlet are intended for use by engineers and others who need to compute displacement, velocity, and acceleration factors for a reciprocating motion controlled by a uniform angular motion. A worked-out example of the procedure in using the tables is given, and the derivation of the exact formulas from which the tables were computed is shown in the appendix.

Elementary Engineering Thermodynamics. By V. W. Young and G. A. Young. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941.

Cloth, 6 × $9^1/_2$ in., 243 pp., diagrams, charts, tables, $2.75. This textbook presents the fundamental theoretical basis for an accompanying course in practical heat engineering. All important topics are covered in a simple, concise manner, with many illustrative examples. The new edition makes use of the more modern Keenan and Keyes steam tables, which were not available for the first edition.

Exterior Ballistics, a reprint of chapters 10 and 12 from "Elements of Ordnance," by T. J. Hayes. John Wiley & Sons, Inc., New York, N. Y., 1940. Paper, 6 × 9 in., 98 pp., illus., diagrams, charts, tables, $1. This pamphlet contains two chapters of Hayes's "Elements of Ordnance," the textbook used by cadets at West Point. These chapters deal with Exterior Ballistics and Bombing from Airplanes, two subjects of direct interest in courses of study connected with the national-defense program. The reprint makes the text available at a modest price.

Gear Design Simplified. By F. D. Jones. Second edition. Industrial Press, New York, N. Y., 1940. Cloth, $8^1/_2$ × $11^1/_2$ in., 139 pp., diagrams, charts, tables, $3. The book consists of a series of charts which illustrate, by simple diagrams and examples, the solution of practical problems of gear design. The types included are spur, straight-tooth and spiral-bevel, helical, herringbone, and worm gears. Information is also provided upon the determination of gearing ratios and speeds and on the power-transmitting capacity of gears. This second edition also contains definitions, a method for checking spur gears, and a table of steels for industrial gearing.

Graphs, How to Make and Use Them. By A. Arkin and R. R. Colton. Revised edition. Harper & Brothers, New York, N. Y., and London, England, 1940. Cloth, 6 × $9^1/_2$ in., 236 pp., illus., diagrams, charts, tables, $3. All the usual methods of graphic representation are clearly and simply explained in this introductory work on the subject. The opening chapters present general principles and proper equipment for graph construction, and a wide variety of uses in business, economics, engineering and other fields is illustrated in the succeeding chapters.

Housing for Defense. By M. L. Colean. Twentieth Century Fund, 330 West 42nd St., New York, N. Y., 1940. Paper, 6 × $9^1/_2$ in., 198 pp., diagrams, tables, charts, maps, $1.50. The problems and experience with regard to housing during the last war are described, with considerable attention to the resulting government policies. The present situation is compared with the past. The relation between housing and the location of defense activities is emphasized, and community problems are discussed. The final chapters deal with the construction and financing of new housing, the relative parts to be played by private and governmental agencies, and the recommendations of the housing committee.

Introduction to the Kinetic Theory of Gases. By Sir J. Jeans. The Macmillan Co., New York, N. Y.; University Press, Cambridge, England, 1940. Cloth, $5^1/_2$ × 9 in., 311 pp., diagrams, charts, tables, $3.50. This book provides such knowledge of the kinetic theory as is required by the serious student of physics and physical chemistry. In the discussions of pressure in a gas, molecular collisions, viscosity, heat conduction, diffusion, etc., the emphasis is on the physicist's needs although the mathematical student will find the necessary basic material from which to proceed to more specialized study.

Lacquer and Synthetic Enamel Finishes. By R. C. Martin. D. Van Nostrand Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 526 pp., illus., diagrams, charts, tables, $5.50. The subject of discussion is the cellulose nitrate and acetate basic lacquers and synthetic enamels as developed in the twentieth century. Part 1 deals with nitrocellulose, solvents, plasticizers, resins, and synthetic compounds, and pigments. Parts 2 and 3 cover plant and equipment, requirements, types, formulation, laboratory and field tests, and faults and corrections. Part 4 describes methods of application and the finishing of furniture and motorcars. There is a very large glossary of paint, varnish, lacquer, and allied terms.

Locomotives on Parade. By E. Hungerford. Thomas Y. Crowell Co., New York, N. Y., 1940. Cloth, $6^1/_2$ × 9 in., 236 pp., illus., woodcuts, diagrams, charts, $2.50. The history of one of the very important mechanical contributions of the last century, the steam locomotive, is told in layman's language. The successive types that evolved are described, including famous individual representatives and the men whose insight and mechanical genius made them possible. There are many photographs and line drawings.

Machine Design. By L. J. Bradford and P. B. Eaton. Fourth edition. John Wiley & Sons, Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 275 pp., illus., diagrams, charts, tables, $3. The object of this text is to supply a brief course which can be covered in about twenty-five lessons, and which will provide a good groundwork of the fundamental facts and processes of machine design. The new edition has been revised to conform with recent developments, especially in ball and roller bearings, gears, and spring design.

Magnetism and Very Low Temperatures. By H. B. G. Casimir. University Press, Cambridge, England; Macmillan Co., New York, N. Y., 1940. Paper, $5^1/_2$ × $8^1/_2$ in., 93 pp., charts, tables, $1.40. The material contained in this booklet, presented originally in a series of lectures, is a systematic account of the field of research dealing with the relation between magnetism and very low temperature states. Special attention is given to paramagnetism and adiabatic demagnetization. There is a list of references.

Materials Handbook. By G. S. Brady. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Leather and cloth, 6 × $9^1/_2$ in., 591 pp., charts, tables, $5. The many materials used in industry are identified and described in this concise encyclopedic reference book. Information is given on physical and chemical properties, constitution, and uses. The materials vary from such basic raw materials as mineral ores and woods to such products as alloy steels and synthetic resins. Intended primarily for purchasing agents and industrial executives, its field is much wider for reference use. Useful tables are appended.

Mechanical Vibrations. By J. P. Den Hartog. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × $9^1/_2$ in., 448 pp., diagrams, charts, tables, $5. In addition to the theoretical presentation of the subject, this textbook presents practical applications to water wheels, steam turbines, automobiles, airplanes, Diesel engines, and electrical machinery. The text has been revised in accordance with recent developments, many new problems have been added, and a comprehensive list of useful formulas has been appended. There is a bibliography.

Mitteilungen aus dem Institut für Baustatik an der Eidg. Technischen Hochschule in Zürich, Mitteilung Nr. 10. Der Durchlaufende Balken auf Elastisch Drehbaren und Elastisch Senkbaren Stützen einschliesslich des Balkens auf stetiger elastischer Unterlage, by A Manger. Verlag A. G. Gebr. Leemann & Co., Zürich and Leipzig, 1939. Paper, 6 × 9 in., 170 pp., diagrams, charts, tables, 12 Swiss fr. A convenient method is developed for calculating all continuous beams with elastically reacting supports. The method is applicable to complicated as well as to simple systems, including systems requiring hinges, and can be used in the analysis of bridge girders. There are many worked-out examples and illustrative diagrams.

Modern Air Conditioning, Heating and Ventilating. By W. H. Carrier, R. E. Cherne, and W. A. Grant. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1940. Cloth, 6 × $9^1/_2$ in., 547 pp., illus., diagrams, charts, tables, $4.50. The whole field of interior conditioning is covered in this manual, which is designed to apply existing theory to actual practice in the industry. Basic theories are explained, but emphasis is placed on the engineering principles and design of equipment. Comfort and economic factors are also considered. Practical examples are presented and worked out in detail, and many useful tables and charts have been collected in an appendix.

Physics of the Air. By W. J. Humphreys. Third edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 6 × $9^1/_2$ in., 676 pp., illus., diagrams, charts, maps, tables, $6. This text provides a comprehensive account of the facts and theories relating to the mechanics and thermodynamics of the atmosphere, to atmospheric electricity, acoustics and optics, and to the factors that control climate. This edition has been revised to include recent information.

Preliminary Airplane Design. By R. C. Wilson, Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1941. Cloth, 5 × $8^1/_2$ in., 67 pp., diagrams, charts, tables, $1. This brief, simple text is based upon the practical procedure used as a guide for instruction at the Air Corps Engineering School at Wright Field. All preliminary design factors are considered, and an appendix contains sample data sheets and weight-control tables.

Schmierstoffe und Maschinenschmierung. By E. H. Kadmer. Gebrüder Borntraeger, Berlin, Germany, 1940. Paper, 6 × 9 in., 479 pp., illus., diagrams, charts, tables, 22.40 rm. Lubricants and machine lubrication are thoroughly covered in this treatise. Nearly half the book is devoted to description of the sources, production, chemical, physical, and electrical properties, analysis, and tests of various lubricants. Their application to bearings, drive gear, cylinders, metal-cutting, and other uses is covered, as is the theory of lubrication and friction. Bibliographies accompany all important sections.

Steel Castings Handbook. Steel Founders' Society of America, Cleveland, Ohio, 1941. Cloth, 6 × $9^1/_2$ in., 503 pp., illus., diagrams, charts, tables, $2. Full of diagrams, data tables, and photographs, this practical handbook covers the cast-steel industry from history to commercial applications. The physical, mechanical, and engineering properties of carbon and low-alloy cast steels are given in detail; production and heat-treatment methods are described; design procedure is considered; and a glossary of foundry terms is included. There are chapter references.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

All Signs Point to New High for Semi-Annual Meeting at Kansas City, June 16-20

A COINCIDENCE of favorable circumstances promises for the A.S.M.E. 1941 Semi-Annual Meeting in Kansas City, Mo., June 16-20, an attendance of members whose participation in the discussions should stimulate to new heights a program combining an intensely interesting and provocative series of technical sessions, supported by correlated inspection trips, with a timely series of sessions on topics of broad professional import to be developed under the auspices of the Engineers' Council for Professional Development.

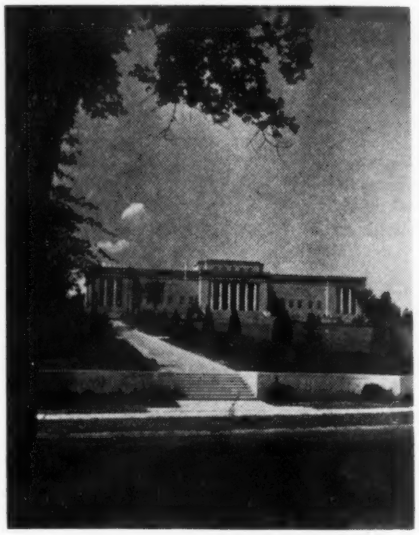
Many Divisions Sponsor Sessions

The A.S.M.E. Petroleum Division will hold its annual meeting cooperatively and concurrently with the main meeting of the Society and will sponsor, as a part of the Semi-Annual Meeting program, nine important papers on petroleum subjects. The Railroad Division will hold an all-day symposium on railroad subjects in the morning, dealing with the topic "Steam Versus Diesel Locomotives" in the afternoon, with "Locomotive Operation and the Cushioning of Draft Gears." The Oil and Gas Power Division will hold its annual meeting in Kansas City the preceding week, so its members may remain over for the Semi-Annual Meeting; and they will want to do so for at least the program of entertainment, the sessions that will deal with petroleum and the Diesel engine for locomotive service, and the sessions on E.C.P.D. activities.

Technical Program Almost Complete

The technical program, although still subject to revision, is almost complete. Besides those mentioned, other topics will be developed under the auspices of the Power Division, the Process Industries Division, the Materials Handling Division, the Fuels Division, the Hydraulic Division, the Heat Transfer Division, the Management Division, and the Committee on Education and Training for the Industries.

Especially noteworthy because of the importance of the flour milling to Kansas City and its vicinity will be a paper on Air Conditioning in Flour Mills, to be sponsored by the Process Industries Division. Under the auspices of a committee set up to promote participation by colleges, three first-prize student papers will be presented by the first prize recipients of Student Groups V, VI, and VII.



Cushing

THE NELSON GALLERY OF ART IN KANSAS CITY, MO.

Kansas City Convention Bureau

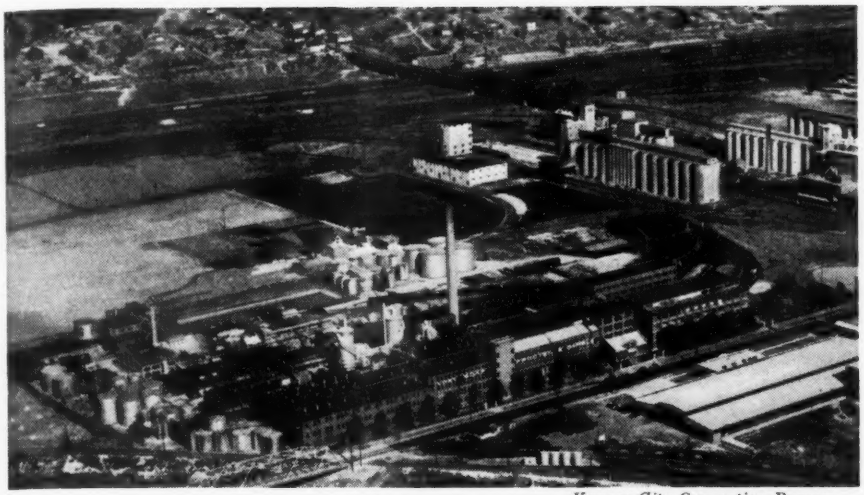
AIR VIEW OF DOWNTOWN KANSAS CITY WITH MUNICIPAL AUDITORIUM IN FOREGROUND

E.C.P.D. Sessions Significant

Significant as the first of its kind ever to be developed for presentation before one of the national societies and promising far-reaching effects, the program being sponsored by the Engineers' Council for Professional Development will attract practicing engineers and educators alike. In the words of Prof. C. F. Scott, under whose direction the participation of the E.C.P.D. in the Semi-Annual Meeting is being developed, the E.C.P.D. program will be "terse and snappy" and pointed to emphasize "concrete and constructive measures for effective action." It will offer to those who attend its sessions an opportunity not only to hear discussed by outstanding engineers topics of vital concern to them, but also to participate in the discussion. The E.C.P.D., Past, Present, and Future; Professional Recognition; Accrediting; Selection and Guidance—these are among the many important topics to be discussed.

Inspection Trips

With a delightfully comfortable air-conditioned hotel, the Muehlebach, as its headquarters, and a city, unsurpassed in many respects in its attractiveness, as its meeting place, the Semi-Annual Meeting will provide opportunities for both pleasant chats with friends and profitable visits to points of cultural and professional interest. Technical sessions have



Kansas City Convention Bureau

AIR VIEW OF KANSAS CITY, SHOWING LARGE INDUSTRIAL PLANTS

been scheduled principally for mornings so as to leave the afternoons free mainly for inspection trips and visits to interesting parts of the city. A completely equipped, modern, aircraft maintenance plant; a municipal auditorium which as an embodiment of modern art and science is a monument to engineering and architecture; a steel mill that is said to be unique in the great variety of steels and steel products that it produces; a strip coal mine which employs an electrically operated shovel that weighs 3,000,000 pounds and has a bucket with a capacity of 32 cubic yards of dirt or almost fifty tons of material in a single cycle; a modern oil refinery; and a modern power plant are among the places to be visited on inspection trips.

The Social End

There will be two general luncheons, one on Tuesday in cooperation with the Kansas City Engineers' Club, the Coal Dealer's Association, the various engineering societies in Kansas City, and the Chamber of Commerce; the other on Wednesday in cooperation with the E.C.P.D., the S.P.E.E., and the Management Division. There will be an informal dinner, with light entertainment, Tuesday evening, followed by an evening session of the E.C.P.D. The banquet will be held on Wednesday evening. A delightful program of entertainment for the women who attend the meeting is being developed. Arrangements for golf privileges will be made at one or more of Kansas City's fine country clubs for those wishing to play golf.

HOTEL MUEHLEBACH, HEADQUARTERS FOR A.S.M.E. SEMI-ANNUAL MEETING

1941 Washington Award to Ralph Budd

RALPH BUDD, president of the Chicago, Burlington, and Quincy Railroad and its subsidiary lines in Colorado and Texas, "father" of the "Pioneer" *Zephyr*, the first Diesel streamline train ever built or operated in the United States, and recipient on January 15, 1941, of the John Fritz Medal, received the Washington Award for 1941, at a dinner held in Chicago, February 24, 1941, "for vision and courageous leadership in advancing the technological frontiers of high-speed railroad transportation." Mr. Budd has been serving as a member of the Advisory Commission to the Council of National Defense, in charge of transportation, since May 28, 1940.

The Washington Award was founded in 1916 by John Watson Alvord "in recognition of devoted, unselfish, and pre-eminent service in promoting the happiness, comfort, and well-being of humanity." It is administered by the Western Society of Engineers on recommendation of a commission representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers. The first award was made in 1919 to Herbert Hoover.

W. L. Abbott, Past-President A.S.M.E., represented the Society at the presentation dinner.

Midwest Power Conference to Be Held in Chicago, Ill., April 9-10

Sponsored by Illinois Institute of Technology With Active Cooperation of A.S.M.E. Chicago Section and Other Technical Organizations

THE Midwest Power Conference to be held in Chicago, Ill., April 9–10, 1941, with headquarters at the Palmer House, offers an opportunity for all persons interested in power production, transmission, or consumption to meet for the study of mutual problems.

Sponsored by the Illinois Institute of Technology, the Conference has the cooperation of many state universities as well as local and national societies, including the Chicago Section of the A.S.M.E. Invitations are extended to all persons interested in the Nation's power problems.

Further information in regard to reservations for the various events and copies of the proceedings of the meeting may be obtained from C. A. Nash, conference secretary, Illinois Institute of Technology, 3300 Federal St., Chicago, Ill.

The preliminary program follows:

Wednesday, April 9

9:00 a.m. Registration, Palmer House, Chicago.

10:15 a.m. Opening Meeting. L. E. Grinter, Chairman.

Address of welcome. Philip Harrington.

Response for the Cooperating Institutions. Huber O. Croft, Mem. A.S.M.E.

Power Facilities and the Defense Program. C. W. Kellogg.

A Résumé of Present-Day Power Trends. A. G. Christie, Past-President, A.S.M.E.

12:15 p.m. Joint Luncheon with A.S.M.E. L. M. Ellison, Mem. A.S.M.E., Chairman.

Speaker: Alfred Iddles, Fellow A.S.M.E. "The User Wants to Know."

2:00 p.m. Central Station Practice. M. P. Cleghorn, Mem. A.S.M.E., Chairman.

Forced Circulation in American Power-Plant Practice. F. H. Rosencrants, Mem. A.S.M.E.

Modern Steam-Turbine Design. C. C. Franck, Jun. A.S.M.E.

Variable-Speed Drives for Power-Plant Auxiliaries. G. V. Edmonson.

Discussion.

3:45 p.m. Hydro Power. Ben G. Elliott, Chairman.

Hydro Power and the National Emergency. Roger B. McWhorter.

The Operation of the Multipurpose Projects of the Tennessee Valley Authority. Sherman M. Woodward, Mem. A.S.M.E.

Construction of 48,000-Hp Kaplan Turbines for the Pickwick Landing Dam of the T.V.A. W. J. Rheingans, Mem. A.S.M.E.
Discussion.
6:45 p.m. "All Engineers" Dinner. Informal (Ladies invited).
Speaker: Dr. Harvey N. Davis, Past-President A.S.M.E. "Priorities in Men."

Thursday, April 10

9:15 a.m. Electric Power Transmission. C. Francis Harding, Chairman.
The Limitations Placed on Power Transmission by System Stability. H. E. Wulfing.
Trends in Equipment Design in Relation to Economics and Defense. W. J. McLachlan.
Discussion.
9:15 a.m. Industrial Power Plants. Hugh E. Keeler, Mem. A.S.M.E., Chairman.
Increasing Power Production With Present Boiler Facilities. R. S. Hawley, Mem. A.S.M.E.
Instruments and Controls Increase Boiler Output. Charles W. Parsons, Mem. A.S.M.E.
Interchange Contracts Between Industrial Plants and Utilities. John T. Davis.
Discussion.
10:45 a.m. Feedwater Treatment. H. E. Hollensbe, Mem. A.S.M.E., Chairman.
Removal of Gases From Boiler Feedwater. Arthur E. Kittridge.
Water-Treatment Problems in the Steam Power Plant. Frederik G. Straub.
Disscussion.
12:15 p.m. Joint Luncheon with A.I.E.E. Frank V. Smith, Chairman.
Speaker: Major Charles W. Leihy. "Aspects of the National Power Pool, Defensively and Afterward."
1:45 p.m. Bus leaves Palmer House for inspection trip through the Tractor Works of the International Harvester Company.
4:30 p.m. Bus returns to the Palmer House.
8:00 p.m. Smoker.

Actions of A.S.M.E. Executive Committee

THE Executive Committee of the Council of The American Society of Mechanical Engineers met at the Engineers' Club, New York, on February 18. President Hanley was in the chair, and there were present Kenneth A. Condit, vice-chairman; Clarke Freeman and K. M. Irwin, of the Committee; Joseph L. Kopf (Finance); J. N. Landis (Local Sections); Victor Wichum (Professional Divisions); W. D. Ennis, treasurer; C. E. Davies, secretary; and Ernest Hartford, executive assistant secretary. The following actions of general interest were taken:

Professional Divisions

On recommendation of the Committee on Professional Divisions, it was voted to change the name of the Aeronautic Division to Aviation Division, and of the Machine Shop Practice Division to Machine Design and Production Division. Approval was also voted of a change of status of the Heat Transfer Group to that of a professional division. Appointments of E. D. Grimison as chairman and W. S. Patterson as secretary of the Heat Transfer Division were confirmed.

National Defense

The Secretary reported that the Committee on National Defense, at its meeting in Washington, Feb. 4, 1941, considered the statement, "Industry Needs Engineers," prepared by Dean Kenneth H. Condit, chairman of the Subcommittee of the National Defense Committee on Selective Service Act. The Committee voted to endorse the statement and to forward it to Dr. Frank B. Jewett, president, National Academy of Sciences, who, at the request of Dr. Dykstra, director of Selective Service, is preparing a statement on the need of engineers in industry. Local Sections chairmen are to be notified of this action, with a copy of the statement and with a letter of transmission indicating that no action on the part of the Local Sections is required.

The statement follows:

Industry Needs Engineers

At their present rate of activity, which is neither what it should be nor what it might be, the national-defense industries of the United States will need by next summer at least twice as many young engineers as the technical schools and colleges can produce. This statement is based on surveys of important industrial areas of the country. What will be the needs when production is in full swing? Certainly not less, and probably far more.

Under these circumstances it is the considered judgment of the members of The American Society of Mechanical Engineers that local draft boards should remember that the production of weapons and ammunition is at least as important as the training of soldiers, and that soldiers without adequate military equipment are nearly helpless in modern warfare.

Production demands skilled workers, and an increasing proportion of these workers must have had engineering training. With demand for engineers already far exceeding actual or potential supply, it would certainly seem wise to hold those that are available now, or will be in June under the present draft law, for industry rather than to classify them as eligible for combat training. As for those now in their junior year, they should be deferred until they have completed their courses at the end of senior year. Members of the engineering teaching staffs subject to the draft are as difficult to replace as any skilled craftsmen or technicians in industry and should therefore be put in Class II.

Some local draft boards have already adopted this policy but many others have not. If the decision in every case is to remain with the local draft boards, then the citizens who make up these boards should have clearly before them the facts set forth in this statement, so that they may not repeat the mistakes that cost France so dearly. If, on the other hand,

Kansas City Convention Bureau

"PETTICOAT LANE" IN KANSAS CITY

(A.S.M.E. Semi-Annual Meeting, Kansas City, Mo., June 16–20. See pages 318–319.)

A.S.M.E. Management Defense Conference Philadelphia, Pa., April 22–23

Sponsored by Philadelphia Section and Management Division

OF paramount importance are the subjects of the sessions to be held at the Management Defense Conference being sponsored by the A.S.M.E. Management Division and the Philadelphia Section on April 22 and 23, with headquarters at the Engineers' Club.

In the following outline of the program there will be found talks both of interest and value from a management viewpoint to all engaged in the national-defense program.

TUESDAY, APRIL 22

Morning Session

Subcontracting Problems

Successful methods of planning and coordination; degree of personal contact between principal and subcontractor; inspection procedure; priority problems.
Three speakers: (1) Office of Production Management official; (2) a representative of a large principal contractor dealing with over a hundred subcontractors; and (3) a representative of a subcontractor.

Afternoon Session

Selection and Training

Speeding learner programs; upgrading workers; selection and training of foremen and subforemen. Specific cases to be given.

WEDNESDAY, APRIL 23

Morning Session

Labor Relations

Panel discussion of current labor problems
Three speakers: (1) Government representative; (2) a union leader; and (3) a representative of management.

Afternoon Session

Quality-Control Problems

Organizing to keep spoiled and defective work at a minimum; supervision of learners; salvaging spoiled work; inspection procedure.
Three speakers to give specific cases and methods.

a policy is to be established by the administrator of the Selective Service Act for the guidance of the local boards, then that policy should be set with the need of industry in mind, and it should be promulgated promptly.

In making this recommendation the members of this Society are well aware that a mechanized army needs engineers for its maintenance and effective utilization, but until we acquire the equipment for such an army it is the part of wisdom to use our young engineers for the production of the equipment we lack. When our military forces are so equipped it will be time enough to apportion the engineers between production and military service to the best possible advantage. In the meantime, if this country is to be the "arsenal of the democracies," it must use its trained men on that job.

We are faced with an enemy whose production machine has been under construction for some seven years and is functioning effectively. It will take all the brains and skill we can muster to close the gap and put ourselves in a position where an offensive against us will be a highly dangerous enterprise. We can ill afford to have our young engineers assigned to duties which do not employ their specialized training. Industry needs every one of them now. Draft officials are urged to recognize that need and classify engineers accordingly.

Finally, there is the vital problem of postwar reconstruction to be considered, and the ruthless economic competition that is sure to accompany it. We shall need engineers for that struggle too. Let us not divert them to less important tasks.

Lamme Medal Awarded to Comfort Avery Adams

The 1940 Lamme Medal of the American Institute of Electrical Engineers has been awarded to Comfort Avery Adams, Fellow A.S.M.E., and consulting engineer, Edward G. Budd Mfg. Co., Philadelphia, Pa., "for his contributions to the theory and design of alternating-current machinery and his work in the field of electric welding." The medal and certificate will be presented to him at the annual Summer Convention of the Institute, which is to be held in Toronto, June 16–20, 1941.

The Lamme Medal was founded as a result of the bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Company, who died on July 8, 1924, to provide for the award by the Institute of a gold medal (together with a bronze replica thereof) annually to a member of the American Institute of Electrical Engineers, "who has shown meritorious achievement in the development of electrical apparatus or machinery" and for the award of two such medals in some years if the accumulation from the funds warrants. A committee composed of nine members of the Institute awards the medal.

Mr. Lamme made similar bequests to the Society for the Promotion of Engineering Education and The Ohio State University, providing in the former for the annual award of a medal "for accomplishment in technical teaching or actual advancement of the art of technical training," and in the latter for the annual award of a medal to a graduate of The Ohio State University in any branch of engineering for meritorious achievement in engineering or the technical arts.

Railroad, Petroleum, Textile Divisions Appoint Research Secretaries

In the March issue of Mechanical Engineering in connection with the statement of the functions and procedures of the A.S.M.E. Committee on Research there were published the photographs of eight official research secretaries who are to serve as liaison officers between their respective Professional Divisions and the Standing Committee on Research.

To this number there have now been added three others: Frank H. Clark, consulting engineer of New York City, has been appointed research secretary of the Railroad Division of the A.S.M.E., Prof. E. E. Ambrosius of the mechanical-engineering department of the University of Oklahoma, research secretary of the Petroleum Division, and J. W. Cox, of the Iselin-Jefferson Co., New York City, research secretary of the Textile Division.

E. E. AMBROSIUS
Petroleum

FRANK H. CLARK
Railroad

A.S.T.E. Adopts Emergency Training Program

An emergency education and training program for the metal-working industry has been adopted and put into operation by the American Society of Tool Engineers. The plan differs radically from Federal plans such as those of the WPA and NYA. It calls for cooperative activity on the part of governmental agencies, industry, and educational boards and facilities to suit the local labor shortage in any given community. It was developed by the A.S.T.E. Educational Committee.

Dean Kimball to Be Speaker at A.S.M.E. Spring Meeting Banquet, April 2

As we go to press, word has been received that Dean Dexter S. Kimball, Past-President A.S.M.E., and Dean Emeritus, College of Engineering, Cornell University, has agreed to take time from his many duties in Washington in the Office of Production Management to speak at the banquet on Wednesday evening, April 2, at the A.S.M.E. Spring Meeting in Atlanta, Ga. His talk will deal with machine-tool priorities in which work he is engaged.

New Names for Aeronautic and Machine Shop Divisions

Heat Transfer Group Becomes Division

The Council of the A.S.M.E., upon the recommendation of the Standing Committee on Professional Divisions, approved a change in name of two professional divisions as follows:

Aeronautic Division is to become Aviation Division

Machine Shop Practice Division is to become the Machine Design and Production Division

The petition from the Heat Transfer Group for the status of Division was also granted. The appointment was confirmed of E. D. Grimison as chairman and W. S. Patterson as secretary of the new Heat Transfer Division.

Personnel of Subcommittee on Machine Design

The correct listing of the personnel of the Machine Design Subcommittee of the Machine Shop Division, now the Machine Design and Production Division, of the A.S.M.E. is:

E. O. Waters, *Chairman*	Frederick Franz
A. E. R. de Jonge	J. H. Marchant

One name on this subcommittee was listed incorrectly in Section Two of the February, 1941, issue of the Transactions of the A.S.M.E.

The Alfred Noble Prize for Younger Members

Awarded for Technical Paper of Exceptional Merit

THE Alfred Noble Prize, the highest honor which is open to a younger member of one of the five national societies—American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and the Western Society of Engineers—was established in 1929 in memory of the late Alfred Noble, a past-president of the American Society of Civil Engineers and the Western Society of Engineers, and an outstanding American engineer. The award consists in a certificate, a cash prize which, dependent on income, is now $350, plus an allowance for the traveling expenses of the recipient to the annual meeting of the society of which he is a member and at which the award is made.

The Alfred Noble Prize is normally awarded annually for "*a technical paper of exceptional merit*" which has been published during the year ending May 31 by one of the participating societies, provided that the author has not passed his thirty-first birthday at the time the paper is submitted for publication "in practically its final form."

"Technical" Liberally Interpreted

The prize committee has always attempted to interpet the term "technical" in a liberal manner. The awards have gone both to papers of a largely descriptive type and to papers of a highly mathematical nature. It is deemed essential, however, that any descriptive paper should be more than a mere general description. It should contain a sufficient amount of factual data, analysis, and detail to make it of more definite value to the profession than a simple "news report."

Similarly, the prize committee feels that no paper of the mathematical type is satisfactory if it offers no promise of practical application. Progress in engineering, it is held, is not measured by research or by theory but by practice. The award is for a technical rather than a scientific paper and practical values are a sine qua non.

Needless to say, the paper must be an individual work of the author, must reflect originality. Presumably, any author will make suitable acknowledgment in his paper for aid or suggestions received from his colleagues or superiors, and all papers are naturally subject to the usual editorial changes of the publisher. A "joint paper," or one which does not reflect individual effort and initiative, is not, however, acceptable.

Similarly, a paper must be of "exceptional merit." The committee recognizes that the junior group in our national societies—both the young engineers in practice and the young men undertaking postgraduate work in an engineering school—have made and are making valuable contributions to the technical progress of the engineering profession. It is natural, however, that many of these contributions will consist of minor improvements in the detail of existing practice or similar extensions of present theory or technique. The committee is thus called upon to undertake to judge when such contributions are sufficiently outstanding as to indicate "exceptional merit." This is, of course, a difficult question and one, in answering which, the committee endeavors to secure the advice and counsel of senior engineers who are experienced in the special field covered by the paper in question.

It is also the view of the committee that the paper should be of a character suitable for presentation at a meeting or for publication in the permanent technical records of the society, i.e., proceedings or transactions. If the Alfred Noble Prize is to be maintained on a high plane of competition, it is inevitable that the burden of proof as to importance and exceptional merit must rest with the paper. Accordingly, the committee, while attempting to keep their standards reasonable, must insist that "exceptional merit" be clearly demonstrated.

Papers are not "entered" for the Alfred Noble Prize. Each year a list of *all* papers which meet the "legal" requirements as to publication, authorship, etc., are studied by an appropriate group within each of the participating societies. The paper recommended by the representative of each society on the Alfred Noble Prize Committee is then considered by the committee and of the papers so submitted one is selected by this committee for the award, or no award is made.

No Award for 1940

Although awards have been made each year for many years past, the Alfred Noble Prize Committee has just, regretfully, announced that there will be no award of this outstanding prize for the twelve months which ended May 31, 1940. It is the sincere hope of the committee, however, that the current year will produce a paper which will receive unanimous approval for this notable junior award.

Aircraft Steel Welding Prize Contest

THE Summerill Tubing Company, Bridgeport, Pennsylvania, is establishing a series of prizes to be awarded by the American Welding Society at its annual meeting during October, 1941, for papers to advance the art of welding of aircraft steels including tubing and other steel parts for tubular assemblies.

The papers may treat of any type of welding which is or can be used for the fabrication of structures or assemblies in the production of aircraft steels such as 1025, X4130, X4135, X4340, or similar steels. They may cover any phase of the problem—joint design, fabrication, or laboratory investigations.

The contest is open to any resident of this country without restriction.

Papers must be submitted not later than August 18, 1941, to the Aircraft Welding Contest, American Welding Society, 33 West 39th Street, New York, N. Y.

H. L. Solberg Appointed Head School of Mechanical Engineering at Purdue

HARRY Leland Solberg, who assumed his duties as head of the School of Mechanical Engineering of Purdue University on February 1, 1941, has been associated with that institution since 1921, receiving the degrees of B.S. and M.S. in mechanical engineering during that period. He was appointed to a full professorship in 1936.

Professor Solberg is considered an authority in the field of steam power and has directed important research in superheated steam at Purdue University, in recognition of which he has been appointed chairman of the A.S.M.E. Critical Pressure Boiler Research Committee.

Courtesy Kansas City Star

A VAST "PARKING LOT" FOR FREIGHT CARS FILLED WITH WHEAT

(Each of these freight cars contains about 1600 bushels of wheat. These cars are "spotted" in the yards at Santa Fe elevator "A" near Turner, Kansas, awaiting disposition. When the wheat is sold on the floor of the Board of Trade the buyer will instruct the railroad where to move it. A.S.M.E. Semi-Annual Meeting, Kansas City, Mo. See pp. 318–319)

Men, Machines, and Plant Capacity Against Time Was Theme of Third A.S.M.E. National-Defense Meeting at Cleveland, March 12-13

HOW to make most effective use of the vast capacity of men, machines, and plants that already exist in this country and that have not yet been drawn into what will become the great all-out program of national defense for the United States and aid to the democracies already at war was the central theme of the papers and discussions at the third of a series of meetings held since last summer by The American Society of Mechanical Engineers and its co-sponsors at the Hotel Statler, Cleveland, Ohio, March 12 and 13. Called the Third Army and Navy Meeting on National Defense, the gathering was sponsored jointly by the A.S.M.E., its committees on National Defense and on Education and Training for the Industries, its Cleveland Section, its divisions on Aviation, Machine Design and Production, Management, and Metals Engineering, and the Army Ordnance Association. Previous national-defense meetings of the present series were held at Pittsburgh, Pa., on September 11, and at Cincinnati, Ohio, October 16 and 17. A fourth meeting is being arranged for Pittsburgh, Pa., on May 2 and 3.

Lend-Lease Bill Sets Tempo of Meeting

Convened within a few hours after the President had signed the Lend-Lease Bill and had begun setting in motion some of the important provisions of that bill, and shortly after the announcement that the Congress would be asked to appropriate seven billion dollars for expenditures, the meeting attracted a total registration of 341 and maintained its printed program with the exception of some luncheon and dinner speakers who were prevented from attending by a combination of the weather and events at Washington. Lt. Gen. Delos C. Emmons, commanding general, G.H.Q. Air Force, Langley Field, was prevented by impossible flying weather from addressing the luncheon on March 12, and Gen. George C. Marshall, Chief of Staff, U. S. Army, and Admiral Harold L. Stark, Chief of Naval Operations, U. S. Navy, missed the dinner on the same day because of official duties at Washington.

Tank Manufacture

George C. Brainard, chairman of the board of the Federal Reserve Bank, Cleveland, and deputy chief of the Cleveland Ordnance District, opened the meeting with a few words of greeting. Two sessions ran in parallel throughout the morning of March 12, one on speeding tank manufacture, with Lt. Col. John K. Christmas, Aberdeen Proving Ground, presiding, at which Frederick A. Stevenson, vice-president in charge of operations, American Car and Foundry Co., New York, N. Y., described the building of combat tanks for the United States Army. The description was supplemented by lantern slides. Discussion held the audience until adjournment for luncheon.

The first session devoted to ammunition manufacture, with Lt. Col. A. B. Johnson, of the Office of the Assistant Secretary of War, presiding, ran in parallel with the tank session. As a curtain raiser, a colored motion-picture film showing the forging of 81-mm shell was presented by the Acme Machinery Company, Cleveland, Ohio, with explanations by H. N. Anderson, sales manager of the company.

All-Out Effort Calls for Improvisation

George T. Trundle, Jr., president, Trundle Engineering Company, placed strong emphasis on the need for improvised methods for rapid munitions manufacture. He cited many instances to show how machines and machine shops not customarily equipped to handle work of the nature called for by the defense program had made excellent records in production. His philosophy was summed up in the statement, "If you don't have the best, use the next best," and he showed how the present situation could be eased by reserving the best machines and men for the most important jobs. Old machines, he said, could be used for roughing operations, and much finishing could be done accurately and economically in secondary operations.

Sam Keener, president of the Salem Engineering Company, Salem, Ohio, said that attention must be given to the development of automatic machines that would be needed to take the load from the improvised machinery as production for defense continued to be needed. He described the Witter shell-forging process which was designed for the semiautomatic forging of shell. Considerable discussion developed over the economics of rough machining of shell forgings by the forging contractor.

> *Fourth*
> **A.S.M.E. National-Defense Meeting, Pittsburgh, Pa., May 2-3, 1941**
>
> THE Fourth A.S.M.E. National-Defense Meeting will be held in Pittsburgh, Pa., with headquarters at the William Penn Hotel. Host upon this occasion will be the Pittsburgh Section of the Society.
>
> The tentative program as outlined by the Section calls for addresses on aircraft production, aluminum, steel, and rubber in defense work; a description of the new plant of the Duquesne Light and Power Company; and talks on heat-treating and controlled atmosphere.

Christmas Talks on Tanks

In the absence of Lt. Gen. Delos C. Emmons, the luncheon address was made by Lt. Col. John K. Christmas, who spoke on tanks. Warner Seely, member A.S.M.E., of the Warner & Swasey Co., Cleveland, Ohio, presided at the luncheon. Lt. Col. Christmas explained why conditions of modern warfare on land had made it necessary to develop the tank which provided heavy fire power, protection for the soldier, and mobility. He spoke in high praise of the tanks being built in this country.

Shell Machining Chart

At the second ammunition session that followed the luncheon, at which Maj. H. M. Reedall, executive officer of the Cleveland Ordnance District, presided, Dr. Max Kronenberg, of the Cincinnati Milling Machine Company, read a paper on coordination of speed, feed, depth, horsepower, tool, and tool life for maximum production. He displayed a chart prepared by him upon which these factors were graphically related, based on the best data available, and checked theoretically with results of investigations in this country and abroad. By means of this "Shell Machining Chart" he demonstrated the solution of many machining problems under various conditions. Although he did not claim that the chart represented the "last word," he believed that it could be useful, especially if it were used as a basis for exchanging data and experiences in shell making.

Two prepared discussions on high-speed cutting materials, one by J. R. Longwell, Carboloy Company, Detroit, Mich., and the other by Philip McKenna, president, McKenna Metals Corporation, Latrobe, Pa., and much discussion from the floor, bore testimony of the interest of the audience in the subject under consideration.

Planning Accelerated Production

At the second afternoon session on Wednesday, which was devoted to aviation manufacture and at which C. H. Dolan, 2nd, chairman of the A.S.M.E. Aviation Division, presided, Arvid Nelson, factory manager, Hamilton Standard Propellers Division, United Aircraft Corporation, Hartford, Conn., spoke on planning for accelerated production. Mr. Nelson reviewed the steps taken by his company to plan for the greatly increased production called for by the expansion of the aircraft industry, and showed pictures of propeller production as it was several years ago and as it is at the present time.

Engineers Accept Challenge of Emergency

About 250 persons attended the dinner on Wednesday evening. The Hon. Frank A. Scott, of Cleveland, Ohio, served as toast-

master. He recalled a former national-defense dinner of the first World War, and the reaction of the nation at the close of that war for peace. He said on that former occasion, and repeated it under present conditions, that if we wanted our voice potent for peace we must keep our arm potent for war. He asked his audience to consider the present situation as a board of directors would consider its chances of a business venture, and then reviewed a number of factors that appeared to weigh heavily in our favor in the national-defense emergency, such as steel-making capacity, machine tools, labor, transportation, and communication.

General Marshall's Message

General Marshall expressed his regret at being unable to be present at the dinner in the following telegram read by Mr. Scott.

I regret exceedingly that duties as Chief of Staff have at the last moment made it impossible to participate in the meeting of the Society.

Your energetic cooperation in converting the funds appropriated by Congress into material essential to the nation's armed forces in the most expeditious manner possible is of vast importance to the security of the nation.

I am confident that your engineering ability and initiative, together with your patriotic purpose, will carry through this tremendous job successfully. Every soldier appreciates what you are doing and is deeply grateful.

Walsh and Hood Speak at Dinner

In introducing Col. James L. Walsh, chairman A.S.M.E. Committee on National Defense, who had been asked to speak in the absence of General Marshall, Mr. Scott recalled Colonel Walsh's connection with the formation of the Army Ordnance Association and its magazine, *Army Ordnance*.

In a stirring address that was enthusiastically received, Colonel Walsh recalled President Roosevelt's statement that the United States was the "Arsenal of Democracy." He pointed out that many arsenals and munitions plants, as well as companies making machine tools, were located in the Middle West. This not only imposed a grave responsibility on the Middle West to speed up production but it also imposed on it a new vulnerability. He attempted to create a picture in terms easy to understand of the enormous size of the defense project and emphasized the importance of time in accomplishing the task. He also dwelt briefly on the problem of civilian defense in which the A.S.M.E. was cooperating with other societies. In closing he said that time for bickering was over. The signing of the Lend-Lease Bill was a turning point in our history and it was up to engineers to deliver the goods.

Speaking on behalf of industry, C. F. Hood, American Steel and Wire Company and president, Cleveland Post, Army Ordnance Association, spoke of the excellent condition of the steel industry and of its ability to meet the national emergency and supply normal needs. He said that industry was ready to "roll up its sleeves" and to meet demands on it with increased confidence and enthusiasm.

Mr. Scott then introduced Charles A. Otis, of Cleveland, who had been a member of the War Industries Board during the first World War.

Gaging Problems Aired

James H. Herron, of Cleveland, past-president A.S.M.E., presided at the session on gaging practices held Thursday morning, and S. B. Terry, chief engineer, Gage Division, Pratt & Whitney, Hartford, Conn., was the first speaker. Mr. Terry reviewed the various types of gages used by industry and their uses and, with the aid of lantern slides, gave a description of the principal types. He was followed by Fay Aller, chief engineer, Gage and Machine Tool Division, Sheffield Gage Corp., Dayton, Ohio, who spoke principally about the multicheck gage by means of which the time necessary for the inspection of dimensions of manufactured products could be greatly reduced. On the subject of gage supply, Elmer J. Bryant, Gage Division, Army and Navy Munitions Board, Machine Tool Committee, Washington, spoke of surveys that had been made to ascertain the gage-manufacturing capacity of the nation. He said that contractors should attempt first to solve their own gage problems and in case they could not they should obtain the assistance of their district ordnance officers. Considerable discussion developed over the question of gages and gage supply.

Machine-Tool Industry on the Alert

At luncheon, Lt. Col. Miles W. Kresge, Ordnance Department, U. S. Army, Washington, presided, and Tell Berna, general manager, National Machine Tool Builders' Association, was the speaker. His subject was "Machine Tools Against Time." Mr. Berna told of the splendid efforts of the machine-tool builders to meet the extraordinary demands of the emergency. The industry, he said, would be able to provide what the nation needed, and to the performance of this task they pledged their lives, their fortunes, and their honor.

Need for Subcontracting Stressed

The two concluding parallel sessions, one on subcontracting and the other on training and recruitment of industrial personnel, followed the Thursday luncheon.

Col. James B. Dillard, general superintendent, Cleveland Twist Drill Co., Cleveland, Ohio, presided at the session on subcontracting and Robert I. Mehornay, Jr., director of Defense Contracts Service, O.P.M., Washington, spoke on subcontracting in defense production. He said that the prime objective of the Defense Contract Service was to get more acceptable materials in less time. Corollary to that came the objectives of spreading the work, getting more bidders and more subcontractors in order that the time element might be solved. The Service, he continued, was anxious to bring about the employment of all idle machinery and skill that could be found and advantageously employed and to facilitate the use of existing plants to the fullest extent. It wanted to be the means of stopping migrations of men into fields already crowded and in which housing problems and the expansion of plants constantly threatened later balanced economy. Full-time technical men employed by the Service were assigned to duty in the immediate area of the potential and actual prime contractors and subcontractors whom they were endeavoring to assist.

"We do not propose to enter private plants and recast their production schedules or processing routines," said Mr. Mehornay. "We can point out the advantages of establishing a subcontracting department and study, with their own production men, the bottlenecks, and the possible acceleration of total production, by shifting parts of the work to subcontractors. We expect these prime contractors to develop in their subcontracting departments detailed information in the form of drawings, specifications, and a description of their own processes for making such pieces; these along with samples of the pieces when available, will be furnished to our appropriate field organization to aid us in locating capable subcontractors."

"Again we do not choose the subcontractor," he added. "We bring a few subcontractors and the prime contractor together to make their own deal. We locate the subcontractors, upon request, and after our technical men and advisers have carefully considered their abilities to do the job, we recommend them to the prime contractor."

"Our field organizations will have considerable information at their command," he explained. "A facility card for each plant, filed and coded and indexed to reflect the available machines, and equipment, the degree of skill, and in the cases of proven ability, the ability to produce certain defense materials or parts thereof. In densely industrialized areas, mechanical selection will be employed and in the leaner areas, industrially speaking, simpler means of selection will be used. But at any office we will be able quickly to select the locations of existing machines from within normal trade groups, and by industrial areas of the territory of that office. Each office will be equipped quickly to select by industrial areas or throughout the office region, the names and locations of contractors of proven ability to produce certain defense materials."

"It is my belief," he said, "that out of our program there will come, at least in part, the solution of the problem. By coordinating with our activities the many efforts which have been made to spread the work of defense, we will all be driving toward the same objectives."

Considerable animated discussion followed the presentation of Mr. Mehornay's paper in which numerous aspects of the subcontracting problem were widely explored.

Training and Recruitment

A. R. Stevenson, Jr., chairman A.S.M.E. Committee on Education and Training for the Industries, presided at the session on training and recruitment of industrial personnel, at which three papers were presented. Dr. Alonzo Grace, Commissioner of Education of the State of Connecticut, described the Connecticut training program and its results. Organizing intensive job instruction was the subject of a paper by Michael Kane, member of the staff, "Training Within Industry," the Advisory Commission to the Council of National Defense, Washington. Lt. B. P. Shirey, Training Officer, Frankford Arsenal, Philadelphia, Pa., spoke on the training of district ordnance inspectors. Discussion of these important subjects held a large audience until late in the afternoon.

Among the Local Sections

Snowstorm Fails to Halt 60 at Anthracite - Lehigh Valley

DESPITE a heavy snowstorm on Feb. 28, the Easton meeting of the Anthracite-Lehigh Valley Section of the A.S.M.E. had an attendance of 60 members and guests. Leopold Tschirky discussed and showed three reels of motion pictures on the manufacture and tests of silica, magnesite, chrome, and basic refractory brick. Discussion followed. During a social period which concluded the program, Mr. Tschirky exhibited some of his 26 reels of colored movies of his travels throughout the world.

Industrial Mobilization Talk Draws 125 Baltimore Engineers

Lt. Col. L. A. Codd, executive vice-president, Army Ordnance Association, presented a talk on the mobilization of industry to meet the needs of the American Army before 125 members and guests of Baltimore Section at a meeting held on Feb. 25. He described how present developments are proceeding according to the general mobilization plan formulated following the World War. Industry is co-operating to the utmost and, in most phases, the defense preparations were said to be up to, or ahead of, the schedule.

Bridgeport Section Features Program on Power Presses

"Industrial Power Presses," a subject considered vital to Bridgeport's defense manufacturing, was discussed by W. M. Evarts, E. W. Bliss Co., Brooklyn, N. Y., at a lecture meeting of the Bridgeport Section on Feb. 18. Films of presses in action were shown.

A.S.M.E. President Speaks to Central Pennsylvania Section

William A. Hanley, President of the A.S.M.E., was the guest speaker at the Feb. 19 meeting of Central Pennsylvania Section. Taking as his topic, "National Defense From an Engineer's Viewpoint," Mr. Hanley stated that the success of the National-Defense Program depends upon the engineer who designs the guns, ships, and other implements of war, and furthers transportation by roads, military vehicles, etc.

Materials Handling Discussed by Maxwell Before Cincinnati

Maxwell C. Maxwell was the speaker at the Feb. 13 session of the Cincinnati Section. He discussed different types of differential hoists and lift trucks and illustrated their commercial applications by means of motion pictures. Their application in a modern foundry was particularly interesting.

Zay Jefferies Describes Strategic Metals to 75 Cleveland Engineers

Zay Jefferies, an expert on metals, talked to 75 members and guests of Cleveland Section at the meeting of Feb. 13 on "Strategic Metals." The talk covered the production and economics of certain metals which are most essential for the prosecution of military activities.

Joint Meeting Held by Members of Colorado A.S.M.E. and A.S.M.

Following an excellent dinner, 95 engineers, members of the Colorado Sections of the A.S.M.E. and A.S.M., heard a talk on Feb. 21 delivered by Dr. O. J. Horger, Timken Roller Bearing Co., on "Strength of Materials, Fatigue, and Photoelasticity." He discussed how these various methods have contributed to improvements in machine parts.

Detroit Section Members Hear Papers on Rubber and Training

Dr. Sidney M. Cadwell, development director of the U. S. Rubber Co., on Feb. 4 delivered before 100 members and guests of Detroit Section a paper on the novel uses of rubber for transportation, vibration isolation, communication, clothing, household wares, and national defense. In the latter field, rubber goes into the manufacture of high-speed military machines, bulletproof tires and gasoline tanks, and improved and lightweight armorplate. Dean Henry B. Dirks, regional director of the engineering training program in the Southern Michigan District, described the work local colleges are doing to train young men for national defense. He urged A.S.M.E. members to take an active part in this program and to assist college instructors wherever possible to meet the great demands being put on them.

East Tennessee Section Hears Paper by L. W. Wallace

"Whither Mankind" was the title of the paper delivered on Feb. 7 by L. W. Wallace, past vice-president A.S.M.E., before 64 members and guests of East Tennessee Section at a meeting held in Knoxville, Tenn. According to J. Mack Tucker, secretary of the Section, it was an excellent paper.

New Place of Engineer in World Discussed at Greenville

Dean R. L. Sackett, guest speaker at the Feb. 11 meeting of Greenville Section, outlined the changing conditions in the industrial world and the changes in attitude of capital and labor. He pointed out that the engineer was in an ideal position to bring capital and labor together because of his ability to see the viewpoints and problems of both sides.

Two February Meetings Held by Los Angeles Attract 200

In accordance with a new policy established this year, Los Angeles Section is holding meetings every month in both Los Angeles and San Diego. At the Feb. 5 meeting in the latter city, 21 members and guests heard a paper on "Conception Engineering" delivered by Norman V. Davidson, and a paper on "Resistance Welding" given by Lorenzo Kennon. The Feb. 13 meeting in Los Angeles attracted about 180 members and guests. Prof. R. L. Daugherty, regional adviser for the engineering defense-training program in the area, spoke on the progress of the program and presented statistics about the number of men supplied and being supplied. He was followed by Harry E. Hjorth, power-plant engineer, Douglas Aircraft Co., who delivered an illustrated talk on the problems incident to the installation of the power plant in the modern airplane, including the development and test work.

Memphis Members Visit and Inspect Mississippi Dredge

Members of Memphis Section made an inspection trip on Feb. 16 to the Dredge *Gulfstream* anchored in the Mississippi River about five miles north of Memphis. This modern and efficient machine was examined very thoroughly by the group.

100 Milwaukee Engineers and Students Listen to Maxwell

About 100 members and student members of the A.S.M.E. were present at the Feb. 5 session of the Milwaukee Section to hear a paper on "Hundred Horsepower Hands" delivered by Maxwell C. Maxwell. In his talk, which was illustrated with motion pictures, Mr. Maxwell described various types of materials-handling devices.

New Haven Section Holds Joint Meeting With Yale Branch

A joint meeting of New Haven Section and the Yale Student Branch of the A.S.M.E. was held on Feb. 18 at the University. Devoted to the topic of aviation, the program featured a talk on his experiences in the civilian pilot training course by George Shepherd, stu-

Kansas City Convention Bureau

VERONA COLUMNS SHOWN AGAINST ONE OF MANY TYPICAL RESIDENCES IN KANSAS CITY'S COUNTRY CLUB RESIDENTIAL SECTION

(A.S.M.E. Semi-Annual Meeting, Kansas City, Mo., June 16–20. See pages 318–319.)

dent member, and a paper by Rudolph F. Gagg, member A.S.M.E. Mr. Gagg showed the essential need of aeronautical engineers for a sound basic training in mechanical engineering and a continuous familiarity with current developments throughout the entire field of engineering. Motion pictures of airplane-engine manufacture at the Wright Aeronautical Corp. in Paterson, N. J., were shown. There were 50 members and 50 student members of the A.S.M.E. present.

Plastics Is Topic of February Meeting of Norwich Section

Plastic materials, their physical and chemical properties, and their application in the manufacture of a great variety of articles, were described by David A. Munns, Bakelite Corporation, before 60 members and guests of Norwich Section at the Feb. 19 meeting held in New London, Conn. A variety of designs were illustrated by slides and by actual sample pieces in various stages of manufacture. The program was completed with a motion picture that showed the manufacture of plastic articles from the raw to the finished stages.

N. E. Funk and E. G. Bailey Speak to 500 Philadelphians

About 425 members and 75 guests of Philadelphia Section were present on Feb. 25 to listen to two fine speakers, N. E. Funk, vice-president, Philadelphia Electric Co., and E. G. Bailey, vice-president, Babcock & Wilcox Co. Mr. Funk traced the progress of improvements in mechanical equipment of power plants from 1902 to 1940, especially as they were applied in his company. Mr. Bailey showed and discussed photographs of combustion processes and flames in furnaces and boilers.

Dinner Meeting in Raleigh Held for Dean R. L. Sackett

Raleigh Section in conjunction with the A.S.M.E. Student Branches at Duke University and North Carolina State University held a dinner meeting on Feb. 6 in honor of Dean R. L. Sackett. Almost 100 people were present. At the dinner, Dean Sackett discussed the professional qualifications of engineers. At the meeting which followed, he outlined the methods to be used in obtaining a job and the qualities necessary for becoming a successful engineer.

125 Members and Wives at San Francisco Ladies Night

More than 125 members and their wives and guests of San Francisco Section attended San Francisco Section's annual ladies'-night party on Feb. 14 at the Clairmont Hotel, and enjoyed the fun, favors, valentines, a fine dinner, an instructive and timely address by Dean Joseph Sinel, and dancing. Dean Sinel, speaking on "Magnificence of Design in Instruments of Destruction," outlined the progress of art from 1918 to the present time where it is being used for bombers and other weapons of destruction. He called upon engineers to lend their aid in supporting the design of instruments of peace which would help the betterment of mankind.

Interest in A.S.M.E. Enhanced by Visit of Dean Sackett to Savannah

W. L. Mingledorff, Jr., chairman of the Savannah Section, reports that the visit of Dean R. L. Sackett to the Section on Feb. 13 has proved very helpful in promoting interest of local engineers in the Society. The 21 members and guests present at the dinner and meeting enjoyed the speaker and his paper.

Turbine Oils Discussed Before St. Louis by K. R. Edlund

The February meeting, on the 28th, of the St. Louis Section featured as speaker Dr. K. R. Edlund, director of research, Shell Oil Co., who presented an illustrated paper on "Modern Turbine Oils." A dinner preceded the meeting which was well attended.

Susquehanna Members Discuss Modern Turbine Developments

J. T. Rettaliata, engineer, Allis-Chalmers Mfg. Co., was the guest speaker at the Feb. 11 session of Susquehanna Section. He started his talk with a short history of turbines and their design, then touched upon general points of design, including blade designs, and concluded with a description of the combustion-gas turbine. More than 60 slides were used to illustrate the talk. An interesting discussion followed.

Virginia Section Holds Two Meetings in February

On Feb. 5, Virginia Section was host to Dean R. L. Sackett, dean emeritus of engineering at The Pennsylvania State College and now assistant secretary of the A.S.M.E. He spoke on the subject, "New Forces Mold Engineering," in which he outlined the place of the engineer in modern industry. On Washington's Birthday, Feb. 22, the Section held a joint all-day meeting with the A.S.M.E. Student Branch at the University of Virginia. Speakers included R. C. Thayer, student member, G. L. Bascome, engineer with the Virginia State Corporation Commission, G. C. Molleson, chairman of the Section, and H. R. Hughes, student member.

Western Washington Officers Honor E. W. Christie of Tacoma

Officers of Western Washington Section, a few friends, and relatives gathered at the home of E. W. Christie in Tacoma, Wash., on Feb. 9 to present him with a Fifty-Year Badge of the A.S.M.E. in commemoration of continuous membership in the Society since 1890. All enjoyed the visit with Mr. Christie and each one went away inspired with the keen mentality of a man who has served so many years in the engineering profession.

Engineering Defense Training Discussed at Washington, D. C.

A small but select group of members and guests of Washington, D. C., Section numbering about 75 heard a comprehensive report of the Engineering Defense-Training Program from Roy A. Seaton, dean of the school of engineering, Kansas State College. Dean Seaton outlined the general plan behind the program and showed how it will benefit the nation. The report was discussed by many members, including Lt. Col. C. E. Davies, Secretary of the A.S.M.E., Warren H. McBryde, Past-President A.S.M.E., Dean S. S. Steinberg, University of Maryland, and Dean A. Scullen, Catholic University.

Waterbury Section Meeting on Plastics Proves Interesting

H. R. Sjostedt, A. L. Alves, and E. W. Soderberg spoke on the subject of "Modern Plastics" at the Feb. 20 meeting of the Waterbury Section. Mr. Sjostedt described several types of plastic materials now in commercial production and showed the differences between the two general classes, thermosetting and thermoplastic. Mr. Alves illustrated with production tools his description of the molding equipment and tools. Mr. Soderberg described the details of injection and compression molding, extrusion, and finishing methods. Many pieces of varicolored articles were used to illustrate the practical applications of plastics. To give the 34 members and guests an idea of how plastic articles are made, a small molding press was set up and operated.

Junior Group Activities

April Meeting of Los Angeles Section to Be Run by Juniors

IN April, the Los Angeles Section of the A.S.M.E. will hold its annual Junior Meeting which will be entirely arranged and conducted by the Juniors. The subject of "Production Machinery and Methods" will be discussed in five short papers presented by Juniors. Industries covered will include aircraft, public utilities, railway equipment, and general manufacturing. Processes to be included will be spot-welding of thin-skin structures, riveting of aircraft, and metallurgical control in industry. Each speaker will be competing for the award offered by the Section for the best paper presented by a Junior during the year.

A.S.M.E. Student Members Are Guests of Metropolitan Junior Group

THE Junior Group of the Metropolitan Section had as its guests the student branches of the local colleges at its regular meeting held on Feb. 11 in the Engineering Societies Building. A. E. Blirer, of Stevens Institute of Technology, was chairman. Speakers for the evening were Philip W. Swain, editor of *Power*, whose topic was "Horse Sense—the Key to Engineering Success," and Adair Rogers, Stewart-Rogers Stoker Co. Inc., Philadelphia, Pa., who discussed his experience as a young engineer in a small company. Student members of the Society from Stevens Institute of Technology, Polytechnic Institute of Brooklyn, City College of New York, and Columbia University were present.

Mr. Swain pointed out that no success is possible without the cooperation of other people and that "horse sense" is necessary to get that cooperation. He added that the successful engineer should speak three languages; the language of engineers, the language of the shopman, and the businessman's language.

Mr. Rogers stated that the greatest weakness of a college education is that it does not teach the value of the dollar. He stressed the importance of modifying the theory to practice.

Following an open discussion the group was entertained with a fencing demonstration by Paul Stevens, former épée champion of Belgium and a member of the Royal Academy of Belgium. Mr. Stevens was assisted by Arthur Nufer and Harvey Hennig, both senior members of the Stevens Institute fencing squad.

With the Student Branches

Oklahoma A.S.M.E. Student Branches Are Guests of Mid-Continent Section

Afternoon Inspection Trips and Presentation of Papers

THE Mid-Continent Section of the A.S.M.E. sponsored its annual student conference Feb. 18 among the A.S.M.E. Student Branches at Oklahoma A.&M. College, Oklahoma University, and Tulsa University. Max R. Wise, section secretary, was chairman of the meeting.

In the afternoon the student members were conducted on an inspection through the Bethlehem Supply Co., Hinderliter Tool Co., and the Spartan School of Aeronautics. The evening session featured papers by representatives from the various Student Branches. Warren Davis, Tulsa University, talked on "Oil and Gas Separators," William Ford, Oklahoma University, discussed "Factors Affecting the Performance of Internal-Combustion Engines," and Robert Le Fever, Oklahoma A.&M. College, talked on "Welded Casings." Each speaker was presented with a $5 bill by E. C. Baker, chairman of the Section, a membership in the Engineers Club of Tulsa by F. W. Robson, director of the Club, and a leather pocket folder and notebook by the Mall Tool Co. The door prize, a pocket rule donated by R. G. Ayers, Bethlehem Supply Co., was won by J. R. Sprague of Oklahoma A.&M. College.

STUDENT CONFERENCE SPONSORED BY A.S.M.E. MID-CONTINENT SECTION, FEB. 18
(Branches at Oklahoma University, Oklahoma A.&M. College, and Tulsa University represented.)

Branch Meetings

MOTION PICTURES entitled, "We Drivers," and "Antifreeze," were shown at the Feb. 26 meeting of Bucknell Branch. The 25 members and guests thoroughly enjoyed themselves.

California Branch started the meeting of Jan. 30 with the lusty singing of school songs under the leadership of Jerry Kushnick. The speaker of the evening was H. P. Stewart, class of '34, an engineer with the shipbuilding division of the Bethlehem Steel Co., who gave a summary of shipbuilding on the Pacific Coast. Refreshments consisted of chocolate cake and ice cream and were greatly enjoyed by the 65 members and guests.

California Tech Branch at the meeting of Feb. 7 discussed the plans for the Student Conference to be held there the first week in April. It is hoped to have Dr. Millikan and an official of the A.S.M.E. as speakers.

Case Branch members assembled on Jan. 17 to hear a talk by Maxwell C. Maxwell on "Hundred-Horsepower Hands." The paper was illustrated with motion pictures.

Catholic University Branch featured a talk and a motion picture on steel and steel products. T. R. Troy, Dodge Steel Company, spoke on the design of steel castings. This was followed by a colored motion picture on pumps and various screw pumps.

Cincinnati Branch discussed so much business at the meeting of Feb. 5 that there was no time left for any papers. Nevertheless, the 84 members enjoyed themselves.

Colorado Mines Plans Conference

At the Feb. 11 meeting, Colorado Mines Branch prepared for the holding of the 1941 Student Branch Conference by appointing the following student members to the general program committee: Howard W. Hicks, C. Burton Folsom, and Donald E. Hollard. This committee will eventually be expanded into several subcommittees.

Colorado State Branch had a student paper given at the Feb. 3 meeting by Ray Barmington. He explained the development and operation of the various types of sugar-beet harvesters still in an experimental stage.

Colorado Branch has several meetings each

year conducted entirely by the student members. At the Feb. 5 meeting papers were given by Willard Brockway, Carroll Stoecker, and Charles Green.

COOPER UNION BRANCH (day) meeting of Feb. 11 was given over to the showing of a film entitled "Sinews of Steel." It was concerned with the development, design, and fabrication of wire rope.

COOPER UNION BRANCH (evening) had a paper on "Steam Generators" presented by Rudolph Bleecher. He not only discussed different types of boilers but also illustrated the various components of each by means of slides.

CASE STUDENT MEMBERS HOLDING DRAW FOR RADIO

(James Climo won when Bob Graham pulled the winning number from the hat held by Bob Wilson.)

Cornell Holds A.S.M.E. Banquet

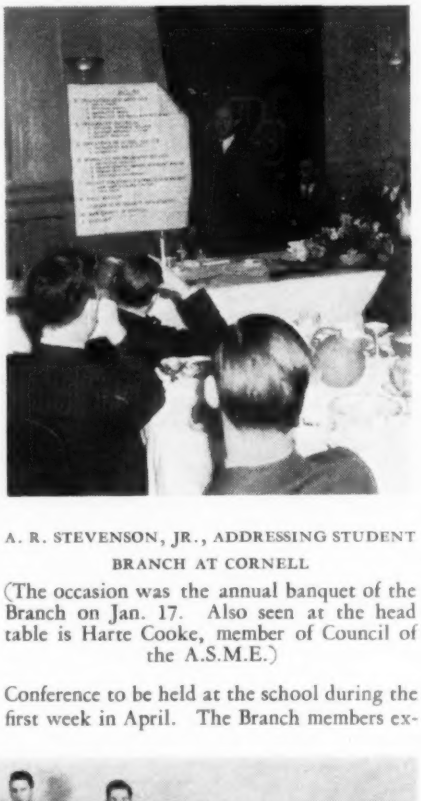
The first annual A.S.M.E. banquet was held by CORNELL BRANCH on Jan. 17. Guest speaker of the evening was A. R. Stevenson, Jr., member A.S.M.E., and an executive of the General Electric Co., who gave a very interesting talk on the development of a product from the conception of the idea to the sale of the finished product. Other guests included Harte Cooke, Dean Dexter S. Kimball, and William N. Barnard. In the opinion of the 85 student members present, this was one of the best affairs yet held by the Branch and plans are already under way to make this an annual affair.

DELAWARE BRANCH has not been heard from until just recently when Harry F. Beik, secretary of the Branch, sent in meeting reports for each month since October. At the Feb. 12 session, plans were made not only for the annual engineers' ball, but also for inspection trips and future meetings.

GEORGE WASHINGTON BRANCH joined with the local chapters of the A.I.E.E. and A.S.C.E. on Feb. 5 in sponsoring a "mixer" meeting which was attended by more than 200. Lieut. Col. Raymond O. Ellison, Ordnance Reserve, U. S. Army, discussed the "Development of Artillery."

Georgia Tech Redecorates Lounge

GEORGIA TECH BRANCH is busy refurnishing and redecorating the student lounge in the mechanical-engineering building. This is in preparation for the annual A.S.M.E. Student Conference to be held at the school during the first week in April. The Branch members extend a cordial invitation to all A.S.M.E. student members to attend the session which, it is promised, will be both interesting and beneficial.



A. R. STEVENSON, JR., ADDRESSING STUDENT BRANCH AT CORNELL

(The occasion was the annual banquet of the Branch on Jan. 17. Also seen at the head table is Harte Cooke, member of Council of the A.S.M.E.)

IOWA BRANCH is sponsoring weekly meetings at which the papers are presented by student members. During the last few weeks, the speakers included G. Hirt, A. Grove, B. Snakenburg, C. Sulkin, C. Schneckloth, George Gero, W. W. Thomas, Ray Latimer, R. Norris, R. W. Miller, C. Noon, and D. C. Morris.

IOWA STATE BRANCH had a record turnout of 150 members and visitors from the student chapter of the A.I.A. at the Jan. 23 meeting. T. Alfred Fleming, supervisor of the conservation department, National Board of Fire Underwriters, as speaker of the evening, discussed building construction in relation to fire hazards. The Jan. 30 session was addressed by A. C. Boock, who discussed the new Allis-Chalmers crawler-type tractor.

KANSAS BRANCH members met on Feb. 20 and heard a paper on "Superfinish," given by Robert Hampel.

Maxwell C. Maxwell at Kentucky

Maxwell C. Maxwell was the guest speaker at the Feb. 14 meeting of KENTUCKY BRANCH. He spoke on the subject of "Hundred Horsepower Hands" and showed several motion pictures about the use of materials-handling equipment.

LAFAYETTE BRANCH is enjoying the biggest year in A.S.M.E. history. More than 42 students have joined so far and it will not be very long before the enrollment is 100 per cent. On Feb. 20, the Branch showed motion pictures on the topics of "Manufacture and Use of Valves," "Manufacture of a V-Type Engine," and "The Power Within."

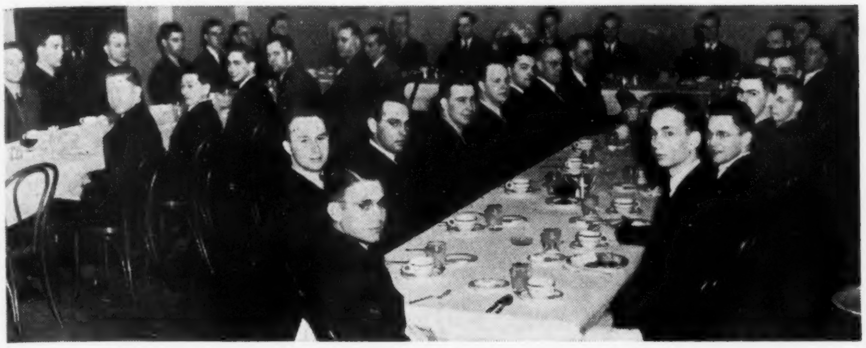
LOUISVILLE BRANCH presented on Jan. 23 the following student speakers: Jack Davis, Frank Reihle, and Perry Wilkes. The student speaker at the Feb. 13 session was Marshall Mallory.

MICHIGAN BRANCH members were very fortunate in having Prof. H. B. Vincent as the speaker on Feb. 19. His subject was the spectroscopy of iron and steel as applied commercially.

MISSOURI MINES BRANCH featured on Feb. 11 a film on lubrication which was presented by A. F. Lyster, Socony-Vacuum Co. An open discussion followed in which all phases of lubrication were covered.

A.S.M.E. STUDENT BRANCH AT MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

(Faculty Honorary Chairman, H. W. Risteen, in front row, sixth from left.)



OREGON STATE STUDENT MEMBERS GATHER FOR A BREAKFAST MEETING ON FEBRUARY 16, THE SECOND HELD THIS WINTER

(This practice is highly recommended to other student branches.)

Dishpan and Soap at Montana

Thayer E. Landes, secretary of the MONTANA STATE BRANCH reporting the Feb. 6 meeting states: "The meeting was called to order by Vice-Chairman George Kanta. It was moved, seconded, and carried that the treasurer purchase a dishpan and a cake of soap with which to wash the Branch's eating utensils. The meeting then adjourned to see a sound movie on Diesel progress."

NEVADA BRANCH members were guests at the home of Dean Sibley for the meeting of Jan. 16. After a talk on a trip to Lake Tahoe given by Michael Tenny, Mrs. Sibley served refreshments to the 15 student members who were present.

NEWARK BRANCH invited William G. Christy, commissioner of smoke abatement for Hudson County, N. J., and member A.S.M.E., to discuss "The Engineers Civic Responsibilities" at the Feb. 10 meeting. Mr. Christy stated that engineers are too backward and let lawyers run civic affairs. As an example of what engineers can do, he cited the recent smoke-abatement campaign conducted by A.S.M.E. members and others in St. Louis.

N. Y. U. BRANCH (aeronautical) had a paper on "The Compressibility Effect in Modern Aircraft Design" delivered by Prof. Henry Vannard on Mar. 5.

N. Y. U. BRANCH (mechanical) planned a meeting for Feb. 19, but this was postponed when the boys had to go and have their pictures taken for the school's yearbook. The Feb. 27 meeting was a joint smoker held in conjunction with the A.I.E.E. chapter. Motion pictures were shown, talks were given by C. S. Lawton and A. B. Wieler, and refreshments were served to all who attended.

Dean Sackett in North Carolina

NORTH CAROLINA STATE BRANCH met jointly with the Raleigh Section of the A.S.M.E. on Feb. 6 for dinner. The guest of honor, Dean D. L. Sackett, gave a very interesting talk on the professional qualifications of engineers. Following the dinner, the group gathered with other members of the A.S.M.E. in Wither's Hall to hear a prepared talk by Dean Sackett. His subject centered around the methods in obtaining a job and the qualities for becoming a successful engineer.

NORTH DAKOTA BRANCH has purchased a radio to be used for the enjoyment of the members. After this announcement at the meeting of Feb. 26, Allen S. King, Northern States Power Company, discussed "Our American Way of Life."

NORTH DAKOTA STATE BRANCH had to change its meeting day from Wednesday to Thursday since the college has inaugurated a national-defense class which is scheduled for Wednesday. At the Jan. 30 session, a motion picture, "Modern Plastics Preferred," was shown.

NORTHEASTERN BRANCH is making great plans for the A.S.M.E. Student Conference being sponsored by it the first week in May. On Feb. 11, committees were selected and put to work preparing for the great event.

Notre Dame Has Movie and Talk

The meeting of NOTRE DAME BRANCH on Feb. 27 was opened with the showing of a motion picture on the "Pennsylvania Turnpike," showing the construction of this super-highway. Following the movie, Vincent Bernard, a student member, delivered a paper entitled, "The Factors to Be Considered in Submitting Bids." Both the movie and the talk were well received by the 25 members and 16 guests.

OHIO STATE BRANCH members heard a talk at the Jan. 31 session on engineering in medieval times as discussed in a paper by Prof. Carl A. Norman. On Feb. 7, Dr. Harold Fawcett spoke on the history of mathematics and the system of numbers.

OKLAHOMA A.&M. BRANCH conducted election of officers at the meeting of Feb. 10. Following this, Will Le Fever described "Welding of Oil Field Pipes," and Frederick Fennema talked about "Plastics in National Defense."

Oregon State Holds Breakfast

The student members of OREGON STATE BRANCH must believe in the old adage that "the early bird catches the worm," because almost 40 of them attended the second breakfast meeting held this winter on Feb. 16. After a hearty breakfast, Prof. Fred Merryfield spoke on "Sulphite-Liquor Waste in Paper Mills." At the conclusion of the talk, the group adjourned to the theater where a sound motion picture "Magic Fibers," was shown.

Purdue Establishes Potter Award

A friend of Dean A. A. Potter, past-president A.S.M.E., has established an award in his honor to be given to the student member of PURDUE BRANCH for submitting the best essay on "The Engineer in Public Service." The award carries with it a cash prize of $50. Another A.S.M.E. member recently honored by the PURDUE BRANCH was Prof. A. G. Young, who was tendered a banquet on Feb. 27 at the Union Building. The program included short talks by E. C. Elliott, president of the University, "Big Robbie" Robertson, and others in addition to a response by the honored guest.

RICE BRANCH welcomed back an alumnus, Wiley Noble, class of '35, as a speaker at the Feb. 12 meeting. Mr. Noble, assistant chief engineer of Reed Roller Bit Company, talked about "Gaging Tool Joints."

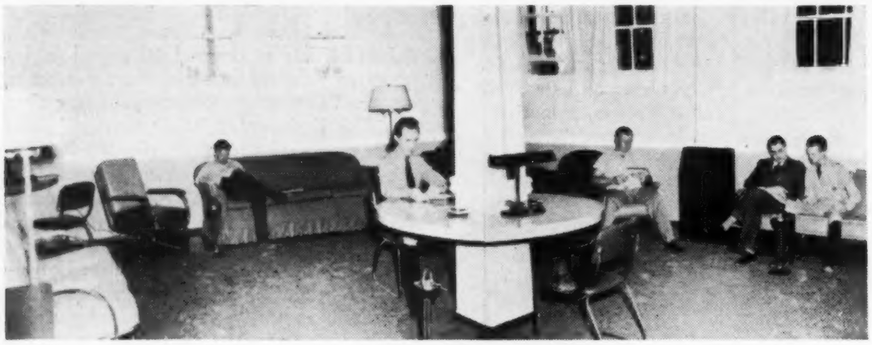
ROSE POLY BRANCH presented a paper on "Heat Transfer," delivered by V. O. Marshall, Devine Process Co., at the Jan. 24 session. The guest speaker at the Feb. 10 meeting was Maxwell C. Maxwell, who talked on the subject of "Home Defense."

SANTA CLARA BRANCH at the meeting of Feb.

STUDENT MEMBERS OF A.S.M.E. RICE INSTITUTE BRANCH ON AN INSPECTION TRIP

(1600 ft below surface in a salt mine at Hockley, Texas, Feb. 22.)

STUDENT MEMBERS OF ROSE POLY ON RECENT TRIP TO LINK-BELT COMPANY IN INDIANAPOLIS



VIEW OF A.S.M.E. LOUNGE ROOM FOR SENIORS, BRANCH AT A.&M. COLLEGE OF TEXAS

(This room is in the basement of the Mechanical Engineering Building and funds for decorations and furnishings came mainly from efforts of seniors in handling storage of students' belongings during the summer of 1939.)

13 had a paper by Paul Steffen, student member, on the work of the Douglas Aircraft Corp.

South Dakota Presents $5 Prize

In order to inspire rivalry among the different classes of students represented in SOUTH DAKOTA STATE BRANCH, a cash prize of $5 will be given to the class which presents the best program during the term. The juniors started the ball rolling on Feb. 5 with a program which featured group singing, a "Walter Winchell" gossip talk by Paul Engebretson, a quiz program, a short play, and lunch.

SOUTHERN METHODIST BRANCH made plans on Feb. 17 for the Engineers' Day demonstrations to be held in the mechanical-engineering department. Following a discussion of plans, a motion picture of the football game between Pittsburg hand S.M.U. was shown while student member Glenn Beasley, a member of the team, described the various plays.

STANFORD BRANCH held its annual initiation dinner on Feb. 13. Fifteen new members were "given the works" by a committee headed by Rudy Pribuss. After all had passed the ordeal with flying colors, A. Neally, Standard Oil Co., gave a paper on "An Insider Looks at the Engineers." He discussed the duties which a young engineer will be called upon to perform during his career.

TEXAS A.&M. BRANCH conducted a morning meeting on Feb. 12. James Petrie, research engineer for the Chrysler Corporation, gave a talk on "Superfinish."

TEXAS BRANCH held an elimination contest on Mar. 3 to select the student members to represent the Branch in a triangular meeting with RICE BRANCH and TEXAS A.&M. BRANCH at Houston on Mar. 17 and 18. Billy Amstead, who read a paper on "Hard Surfacing by Oxyacetylene Welding," and A. D. Payne, who talked on "Instrumentation for a Study of Steam Distribution Systems," were selected as the representatives.

VILLANOVA BRANCH for Feb. 18 had as guest speaker, E. L. Hopping, chief mechanical engineer, Philadelphia Electric Co. He discussed the mechanical-engineering problems encountered in an electric power company. On Feb. 27, the student members were given an insight into these problems when they were taken on an inspection trip through the Schuylkill Power Station of the Philadelphia Electric Co.

WASHINGTON BRANCH officers have decided to draft all those members who do not volunteer to serve on the ten committees formed at the Jan. 16 meeting for the coming A.S.M.E. Student Conference for which the Branch will be host.

WASHINGTON UNIVERSITY BRANCH was presented with a problem at the Feb. 11 meeting—to keep the school clock running. Student members Telle and Martin were appointed to work out a solution.

A.S.M.E. Local Sections

Coming Meetings

Akron-Canton. April 17, 1941. At 5:30 p.m., inspection trip through New Timken Vocational High School. Subject: "Mechanical and Metallurgical Problems in Aircraft," by R. R. Moore, chief metallurgist, Naval Aircraft Factory, U. S. Navy Yard, Philadelphia, Pa.

Anthracite-Lehigh Valley. April 25, 1941. Reading (exact place not definite) at 8:00 p.m. Subject: "Textiles," by R. De Vere Hope. There will be a 15-minute talk on "Defense Education and Training Programs," by W. T. Spivey, director—Region 6 E.D.T., Philadelphia.

Baltimore. April Meeting. Subject: "Research and Its Place in Industry," by L. W. Wallace, director engineering and research division, Crane Company, Chicago, Ill.

Chicago. May 9. Imperial Room, Chicago Towers at 6:30 p.m. Annual Meeting and election of Section officers, reception to President William A. Hanley. Subject: "Why National Defense—an Engineer's Viewpoint," by William A. Hanley, President of The American Society of Mechanical Engineers.

Detroit. April 1, 1941. L'Aiglon, Fisher Building, Detroit, Mich. Dinner at 6:30 p.m.; session at 7:45 p.m. Subject: "Glass in Industry," by C. J. Phillips, sales manager, Corning Glass Company.

Ontario. April 10. Hart House, University of Toronto; dinner 6:30 p.m.; meeting at 7:30 p.m. Subject: "Why Time Study," by R. S. Presgrave, J. D. Woods, Co., Toronto, Ont., Can.

Philadelphia. April 22. Engineers' Club of Philadelphia, at 8:00 p.m. Subject: "Fabrication of Lightweight Materials."

St. Joseph Valley. April 15. Notre Dame, Engineering Auditorium. Subject: "Problems in Aircraft Production."

Washington, D. C. April 10. Pepco Auditorium at 8:00 p.m. Subject: "The Steam-Electric Locomotive," by C. M. Davis, engineer, Transportation Division, General Electric Company.

Waterbury. April 9. Hotel Elton, Waterbury, Conn., at 6:30 p.m. Subject: "Hat Manufacture and the Machinery Involved," by Frank H. Lee, Jr., president of the Frank H. Lee Company, Danbury, Conn. A sound movie, "The Lee Hat Parade," will be shown.

Woman's Auxiliary to A.S.M.E. Honors Mrs. G. W. Farny

MRS. George W. Farny was guest of honor at a luncheon on Tuesday, January 28, at the Engineering Woman's Club, 2 Fifth Avenue, New York City. The luncheon was given and attended by women who had served on the executive board of the Woman's Auxiliary to the A.S.M.E. with Mrs. Farny during her presidency.

The table was decorated with spring flowers, yellow candles, and flowered place cards. An antique Sheffield silver platter was given to Mrs. Farny. Mrs. Calvin W. Rice who was in charge of the luncheon made the presentation.

(*A.S.M.E. News continued on page 332*)

Men and Positions Available

Send inquiries to New York Office of Engineering Societies Personnel Service, Inc.

29 W. 39th St. New York, N. Y. | **211 West Wacker Drive Chicago, Ill.** | **57 Post Street San Francisco, Calif.** | **Hotel Statler Detroit, Mich.**

MEN AVAILABLE[1]

GRADUATE MECHANICAL ENGINEER, license. Plant engineer of large plant, program nearing completion. Ten years' experience highway, laboratory, specification, plant engineering, heating, lighting, ventilating. Desires position plant, materials-handling engineer. Me-614.

MECHANICAL ENGINEER, B.S.M.E., M.M.E., desires assistant professorship in machine design. Now employed teaching design and related subjects in recognized engineering college. Has had industrial experience in machine design. Me-615.

JUNIOR ENGINEER AND MACHINE-TOOL DESIGNER, 26, assisted consulting engineer 4 years, evenings, in design of automatic soldering and grinding machines. Two years design of punches, dies, and automatic machines. Now employed. Me-616.

[1] All men listed hold some form of A.S.M.E. memberseip.

MECHANICAL ENGINEER, 43, thoroughly experienced in design, production, and plant management, capable of meeting problems of development and manufacture and keeping a plant functioning smoothly and efficiently. Me-617.

PLANT SUPERINTENDENT, 33, married. Well-balanced experience in machine shop, sheet metal, forging, and assembly. Thoroughly familiar with planning schedule and time study. Established record for cost and scrap reduction and economical plant operation. Now employed. Me-618.

MECHANICAL ENGINEER, 35. Twelve years' experience steel-mill operation, maintenance, construction, layout, cost control, investigations, utility services, plant protection, lubrication. Employed present position 10 years, assistant to chief engineer. Me-619.

RESEARCH AND DEVELOPMENT ENGINEER, M.E., licensed, married. Creative ability, broad practical experience as machinist, instructor in machine work, chief engineer large water-wheel manufacturer, consultant hydroelectric power development, domestic stokers, etc. Metropolitan area. Me-620.

MECHANICAL ENGINEER, 33, University graduate, 1928. Experience: machinery lubrication, oil-refinery instrumentation, power-plant operation and testing, automotive testing, textile-plant maintenance. Me-621.

M.I.T. graduate, with 18 years mechanical-engineering and teaching experience, desires position as instructor of engineering or mathematics subjects, in factory schools, trade, or private schools. Me-622.

EXECUTIVE, now available. Fifteen years with last employer, establishing earning power in excess of $20,000. Graduate M.E., wide experience in design, construction, and management of heavy-type manufacturing plants. Me-623.

RESEARCH AND DEVELOPMENT ENGINEER, 28, B.S. in M.E. Experienced, familiar with design of pumping equipment, particularly that of low-pressure applications. Capable of conducting, recording, and reporting tests. Ability to work on own initiative and in harmony with associates. Me-624.

MECHANICAL AND ELECTRICAL ENGINEER, B.S., M.S., and M.E. degrees; registered professional engineer. Extensive experience in consultation, design, and construction of high- and low-pressure power plants for heavy and process industries. Me-625.

INSTRUCTOR IN MECHANICAL ENGINEERING, 28, single, B.S., M.S., has taught hydraulics, thermodynamics, machine design, air conditioning, power plants, engineering economics, and laboratory. Two years' industrial experience. Me-626.

SALES EXECUTIVE ENGINEER, broad technical, business, and legal training, law degree. Ten years designer and engineer steel plants; twelve years machine-tool salesman, dealer, sales manager, general manager leading machine-tool concern. Me-627.

POSITIONS AVAILABLE

MECHANICAL ENGINEER thoroughly experienced in production of small precision parts. Must be familiar with quality control, tooling gages, and precision measurements. Position offers attractive opportunity for capable man with medium-sized manufacturer. Apply by letter giving details of education and experience. Connecticut. Y-7499.

GRADUATE ENGINEER with reasonable knowledge of good engineering practice in following fields: natural-gas industry, recycling and gas lift, steam, Diesel, refinery, chemical work (chemical engineering and construction), municipal. Must be able to organize and direct engineering, purchasing and field construction for this class of work. Excellent opportunity. Salary, $400-$600 month. Middle West. Y-7501-C.

MECHANICAL ENGINEER, 28-32, graduate of recognized engineering college, with four or five years' experience since graduation in process industry. Should have experience in practical application of sound engineering principles. Knowledge of steam flows and application, power generation and distribution, plant maintenance, installation and layout, design, and construction would be beneficial. Salary open. New Jersey. Y-7523.

PLANT ENGINEER, mechanical, to take entire charge of all equipment, installation of machinery, maintenance, etc. Salary, $6000-$7500 year. Middle West. Y-7562.

PRODUCTION AND CONTROL ENGINEER who can take complete charge of production, scheduling, and planning for large manufacturing company. Salary, $7500 year. Middle West. Y-7563.

INSTRUCTOR, 30-45, for presentation of classes in industrial supervision, i.e., human and personnel relations, control methods and procedures, industrial-relations policies and problems, conference-leading technique, etc., to be taught by explanation, demonstration, application, repetition, examination, and correction. Must have teaching experience and thorough knowledge of production, management, control, design, and methods. Salary, $300-$350 month. West Coast. Y-7592C-S.

TOOL ENGINEER capable of layout of jigs for cost reduction in plant manufacturing machine tools to work in methods department. Should be able to outline type of tools and possible savings resulting from their use, work in coordination with present tool-design and toolroom. Experience in tool design essential; also familiarity with production requirements on small-quantity manufacture, ranging in lot sizes from 10 to 400 pieces. Salary, $55-$65 week start. East. Y-7596.

ENGINEER to take charge of standards department of company manufacturing paper box board and wax paper. Man should have point-system experience and be able to fur-

(*A.S.M.E. News continued on page 334*)

A.S.M.E. Calendar

of Coming Meetings

March 31-April 3, 1941
Spring Meeting
Atlanta, Ga.

April 3-4, 1941
Textile Division Meeting
Greenville, S. C.

April 22-23, 1941
National Management Conference on Defense
Philadelphia, Pa.

June 11-14, 1941
Oil and Gas Power Division
Kansas City, Mo.

June 16-20, 1941
Semi-Annual Meeting
Kansas City, Mo.

June 20-21, 1941
Applied Mechanics Division
University of Pennsylvania
Philadelphia, Pa.

October 12-15, 1941
Fall Meeting
Louisville, Ky.

October 30-31, 1941
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Lafayette College
Easton, Pa.

December 1-5, 1941
Annual Meeting
New York,
N. Y.

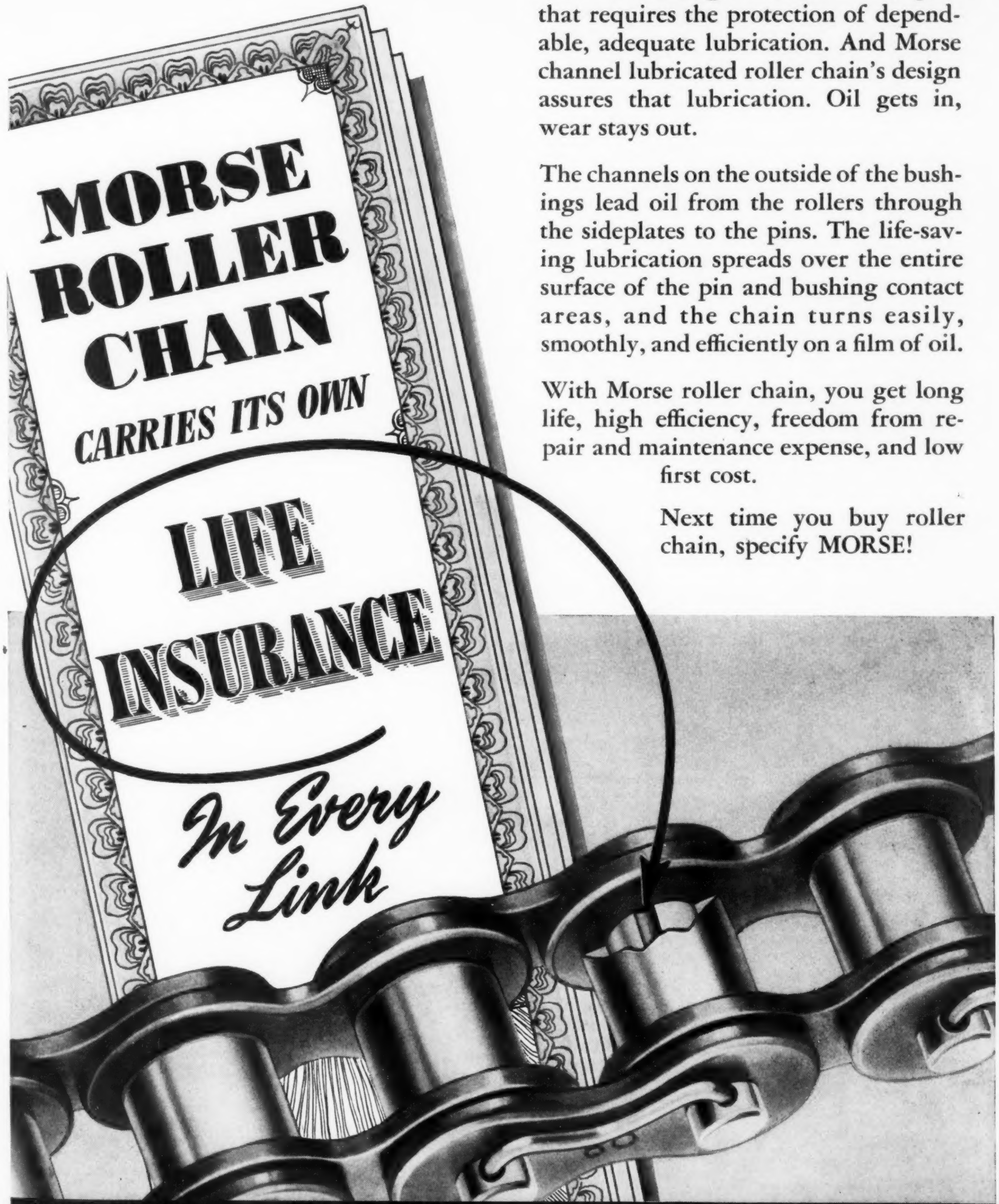
(*For coming meetings of other organizations see page 22 of the advertising section of this issue*)

THE HEART of a roller chain—the pin and bushing surfaces—is the part that requires the protection of dependable, adequate lubrication. And Morse channel lubricated roller chain's design assures that lubrication. Oil gets in, wear stays out.

The channels on the outside of the bushings lead oil from the rollers through the sideplates to the pins. The life-saving lubrication spreads over the entire surface of the pin and bushing contact areas, and the chain turns easily, smoothly, and efficiently on a film of oil.

With Morse roller chain, you get long life, high efficiency, freedom from repair and maintenance expense, and low first cost.

Next time you buy roller chain, specify MORSE!



SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE positive DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

nish satisfactory references. Salary, about $50 week. Southwest. Y-7619.

MECHANICAL ENGINEER, not over 30, with some machine-design experience; one or two years' experience in mining or conveying machinery desirable, for development work in manufacturing company. Salary, $200 month. New Jersey. Y-7623.

WORKS MANAGER, 35–50, thoroughly experienced in modern production methods, supervision, and organization. Prefer applicant with some experience in silverware industry but will consider man with experience in soft-metal manufacturing. Salary open. New York State. Y-7634.

MECHANICAL ENGINEER preferably with electrical experience, to act as assistant to vice-president in charge of engineering design of complicated underground coal-mining machinery. Experience in mining or automotive field desirable but not essential. Must be able to coordinate efforts of specialty engineers. Middle West. Y-7636-C.

ASSISTANT PLANT SUPERINTENDENT with experience both in operating and supervising of operation of machine-tool equipment, such as automatic-screw machines, punch-power presses, hand-screw machines, lapping machines, and other special equipment. Permanent. Excellent opportunity. New Jersey. Y-7637.

MECHANICAL ENGINEER with maintenance experience on boats—internal-combustion engines, electrical equipment, etc. Company manufactures motor torpedo boats. Salary open. New Jersey. Y-7644.

ELECTRICAL OR MECHANICAL ENGINEER, preferably young graduate, for testing laboratory of company manufacturing electrical appliances. Work will involve testing of products in process of development as well as finished production. Excellent opportunity. New England. Y-7650.

DRAFTSMAN with 5 years' experience on small electromechanical devices. Apply by letter stating age and details of education, experience and salary expected, and enclose sample of work. New England. Y-7662.

DESIGNERS who are graduate mechanical engineers and have considerable experience in design department of heavy-machinery industry, especially wire-manufacturing equipment. New York State. Y-7667.

DESIGNERS experienced in design of automatic machinery for processing industries; for instance, in paper, food, textiles, or rubber plants. Salary, $60–$65 week. Also require mechanical draftsmen with experience in machine detail work. Salary, $50 week. New York State. Y-7679.

ASSISTANT MANAGER, about 40, for manufacturing plant employing about one thousand people. Should have scientific or engineering background and several years' experience in factory management. New York State. Y-7684.

GRADUATE MECHANICAL ENGINEER with 2 to 3 years' experience in testing. Will work on centrifuge machines, study present machine and prepare specifications and layout, and supervise installation. Should have chemical background. Prefer married man. Salary open. N. Y. metropolitan area. Y-7689.

DESIGNERS, graduates of technical schools, not over 35, who are experienced in design of hydraulic turbines or other hydraulic equipment, large valves, gates, and hoists. Should be familiar with principles of hydraulics or applied mechanics. Must be American citizens. Pennsylvania. Y-7691.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after April 25, 1941, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member

NEW APPLICATIONS

For Member, Associate, or Junior

ALLARDT, ERNST W., Cleveland, Ohio (Rt)
BEATTY, W. C., Canton, Ohio
BERNARDIN, OTTO F., New York, N. Y.
BONNEY, ROBERT H., East Peoria, Ill.
CARTER, LOUIS E., Baltimore, Md.
CLARK, HENRY L., San Francisco, Calif. (Rt & T)
CRASHAW, S. L., Pittsburgh, Pa.
FARRINGTON, STEPHAN G., New York, N. Y.
FOELL, CHARLES F., New York, N. Y.
FORTIER, HENRY J., Irvington, N. J.
FUETTERER, RUDOLPH E., Berkeley, Calif.
GALL, ALEXANDER H., Detroit, Mich. (Re)
GANNETT, MALCOLM F., York, Pa.
GAYA, WILLIAM L., St. George, S. I., N. Y.
GREINER, JOS. C., Toledo, Ohio
HINES, GEO. E., Indianapolis, Ind. (Rt)
HINTON, WM. A., Atlanta, Ga.
JOECKEL, STANLEY V., New York, N. Y.
JOOS, CHARLES E., Philadelphia, Pa. (Rt)
KENT, ALLAN D., Kingston, Ontario, Canada
KITTREDGE, A. E., Audubon, N. J. (Rt & T)
LATULIPPE, L. J., Sherbrooke, Quebec, Canada
LOEFFLER, J. E., Houston, Texas
MAHEN, KENNETH W., Wilmington, Del.
MANCHESTER, WARREN L., Los Angeles, Calif.
MCBURNEY, WILLARD B., Atlanta, Ga. (Re)
MACNAMEE, WM. R., Philadelphia, Pa.
MOORE, WALTER G., Berkeley, Calif.
MURRAY, AUBREY S., Elizabethton, Tenn.
NAYLOR, HENRY A., JR., Baltimore, Md.
O'CONNOR, WM. D., Wauwatosa, Wis.
PARKER, NORMAN A., Boulder, Colo.
PAUL, R. F., Narberth, Pa.
PECK, CHAS. V., New York, N. Y.
PERLEY, A. M., Portland, Oregon
PHILBRICK, GEORGE A., Sharon, Mass.
POWELL, SHANNON C., Quincy, Mass.
OATES, FRANK R., New York, N. Y. (Rt)
ROBERTS, KENNETH C., Knoxville, Tenn.
ROSSI, BONIFACE E., Jackson Heights, L. I., N. Y.
RUTH, DANIEL H., Waynesboro, Pa.
STEINMETZ, ARTHUR M., New York, N. Y.
SULLIVAN, FRANCIS J., Manhattan, Kan.
SULTZER, NORMAN W., New York, N. Y.
WALSH, FRANK O., JR., Atlanta, Ga.
WEISS, HERBERT A., Potsdam, N. Y.
WENTWORTH, HARRY T., South Orange, N. J.
WHITE, JAMES J., Overbrook, Pa.
WILCOX, DONALD B., Atlanta, Ga.
WRIGHT, STANLEY, New York, N. Y. (Rt)
YOUNG, WILLIAM T., Reading, Pa.

CHANGE OF GRADING

Transfer to Fellow

SCHLINK, FREDK. J., Washington, N. J.

Transfers to Member

BARATTA, HENRY E., Washington, D. C.
BARTA, GEORGE L., JR., Jackson Heights, L. I.
BUTROVICH, GEO. WM., Santa Monica, Calif.
CADWALLADER, LEWIS W., Silver Spring, Md.
DANN, WILLARD J., Chicago, Ill.
HJERPE, NORMAN F., Seattle, Wash.
KLINE, LEE A., Niles, Ohio
LIMBACHER, HOWARD R., Columbus, Ohio
O'BRIEN, FRANK L., JR., Philadelphia, Pa.
SCHAEFER, CONRAD B., New York, N. Y.
STERN, ARTHUR C., New York, N. Y.
TREIBER, KENNETH L., Newark, N. J.
TUTT, CHAS. L., JR., Princeton, N. J.
UMÉREZ-BLANCO, FRANCISCO G., Caracas, Venezuela

Transfers from Student-member to Junior—72

A.S.M.E. Transactions for March, 1941

THE March, 1941, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

- Displacements Determined by Airy's Stress Function, by H. M. Westergaard
- Influence Surfaces for Stresses in Slabs, by F. M. Baron
- Chart of Air-Vapor Mixture Properties at Different Pressures, by R. C. Binder
- Transient Torques in Induction-Motor Drives, by A. M. Wahl
- An Eddy-Current Method of Flaw Detection in Nonmagnetic Metals, by Ross Gunn
- An Extension of the Photoelastic Method of Stress Measurement to Plates in Transverse Bending, by J. N. Goodier and G. H. Lee
- Notes on the Dynamics of Electric Locomotives, by B. S. Cain

DESIGN DATA

- Vibration Problems, by A. L. Kimball

DISCUSSION

- On previously published papers by H. Poritsky and H. D. Snively; and J. N. Goodier